Evaluation of the mineral status of organically grown cotton in Egypt

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1 Introduction

For the last two centuries, Egyptian history was closely linked to the production of the famous high quality “Mako Egyptian cotton”: profits from cotton cultivation enabled the political leaders to realize their visions and to become wealthy at the farmers´ expense. Due to favourite soil conditions, cotton production is traditionally concentrated in the Nile valley and the delta, where - still to this day - small farms (average size: 0.63 ha) predominate (FAO, 2005).

It was Mohammad Ali Pasha (May, 17 1805-March 2, 1848), who introduced the American cotton species *Gossypium barbadense* to Egypt. First, he confiscated the feudal farms of the Mameluk grandees, ordered a wide-scale planting of cotton and sold the harvest to the fast expanding textile industry abroad. Next, he ordered the majority of Egyptian peasants to cultivate cotton at the exclusion of other crops, bought the entire crop himself and resold it at market-price especially to English textile industrialists. This is how he financed numerous technical innovations, i. e. the construction of irrigation canals and delta barrages (Lewis, 2009).

After the Lancashire cotton famine, a depression of the English textile industry caused by the American Civil War (1861-1865), which led to an interruption of baled cotton imports from America and a break-down of the world’s textile market, Egyptian-grown cotton was in turn strongly promoted[1]. British and French traders invested heavily in cotton plantations and the Egyptian government of Isma'il Pasha (January 19, 1863-June 26, 1879) took out substantial loans from European bankers and stock exchanges. After the end of the American Civil War, British and French traders abandoned Egyptian cotton and returned to cheap American exports. Egypt - as consequence - ran into deficit, declaring bankruptcy in 1876, a key factor behind Egypt's annexation by the British Empire in 1882 (wikipedia, 2010).

During the English protectorate, technical achievements were attained like the first (1912) and second (1933) elevation of the Aswan Dam and a large agricultural drainage network in Lower Egypt. But smallholders did not profit enough from the cash-crop cotton. Often, they were not able to gain enough living from their farms (Nofal, 1995).

This was one reason why Gamal Abdel Nassar (July 20, 1952-September 28, 1970) implemented the socialist land-reform between 1952 and 1969. Large estates were expropriated, maximum farm size was limited and farmer’s cooperatives were established (Nofal, 1995). Farmers were obliged to deliver cotton and other agricultural products at fixed prices to the government. A basic cropping pattern was prepared for each village, specifying quantity, crop variety as well as quantity and type of fertilizers and pesticides to be supplied to farmers (FAO, 2005). The most important technical achievement in this period was the completion of the Aswan High Dam in 1970.

[1] In 1862, the first double-engine plowing system, produced by the English John Fowler & Co and equipped with a clipdrum-system, arrived in Egypt. The Egyptian vice-emperor Halim Pasha, son of Mohammad Ali Pasha, hoped to increase productivity of cotton cultivation by means of this machinery. But the two mechanics, who were supposed to set the machine into operation, failed to get them to work: due to the annual flooding of the Nile, the heavy machines sunk into the muddy ground and it was impossible to get them working. It was the famous German - Max Eyth - an agricultural engineer who had further developed the winches used with the Fowler’s plough, who was sent to Egypt. It took him several months to get the ploughs working satisfactorily (Eyth, 1949).

Agricultural politics changed after the assassination of Muhammad Anwar as-Sadat (October 15, 1970-October 6, 1981), whose successor was Muhammad Husni Mubarak (October 14, 1981-February 11, 2011). Mubarak introduced significant reforms concerning a loosening of price-fixing, market control, delivery quotas for main crops and reduced subsidies for inputs. In any case, the Mubarak regime managed to keep a hold of the monopoly for cotton trading until its end, fixing inland-prices for cotton and still dictating the varieties to be cultivated in different governorates (Nassar and Salama, 1997). Farmers - the vast majority of them still being smallholders - had to cope constantly with rising production costs due to the diminishing subsidies and to rising prices for fertilizers and energy due to world market influence (Oxford Business Group, 2009). The inconsistant governmental price-policy for cotton resulted in greatly fluctuating production rates, as farmers in case of low guaranteed cotton prices swiftly changed to other crops in the following season (Global Agricultural Information Network, 2010).

It is still uncertain what will come after the revolution of the Egyptian people in spring 2011. A transitional military government has taken over until free elections will be held from from 21st of November 2011 until 4th March 2012 (Fahmy, 2011). Hopefully, the Egyptian smallholders will profit from the changes in the long run. The production of organic cotton could indeed improve their economic situation, if farmers could profit from the comparably high prices attained for this product on the market.

Gossypium barbadense from Egypt remains a synonym for high-quality cotton, although the competition from other countries is strong: with a world production level of around 24 m tons, Egypt ranks on the 15th position of all cotton growing countries (wikipedia, 2010) with an annual production of 125,000 tons (lint, season 2008/2009). Despite this small production volume, around 20 % of the Egyptian agricultural exports refer to cotton (Egypt State Information Service, 2010).

Cotton (organic and conventional) in Egypt is almost exclusively grown on the Old Land, on alluvial soils of the Nile Valley and the Delta Region (Global Agricultural Information Network, 2009). According to FAO-typisation of agricultural used soils they can be classified as Fluvisols, Vertisols and - if affected by high salt concentrations – as Solonchaks (FAO, 2006). All soils have in common the influence of historical annual floodings which ceased in 1970 with the inauguration of the Assuan High Dam. There is virtually no precipitation. All cotton fields are watered by inefficient flood irrigation and most of them are connected to drainage systems (FAO, 2010). Drainage systems on the one hand prevent the land from waterlogging and salinization. On the other hand, the drained salt-loaded water is diluted, reused for agricultural purposes and in this way contributes to further salinization. Moreover, salinity in the North of the Delta is due to water-intrusions from the Mediterranean Sea (Oosterbaan, 1999). Urbanization, industrialization and the use of chemicals influence the quality of irrigation water and soils (EEAA, 2004).

Conventionally produced cotton is considered as the agricultural product with the highest use of chemicals for pest-control and fertilizing purposes. 18 % of the chemical plant protection active ingredients are used worldwide on cotton fields, which represent only 0.8 % of the cultivated areas in the whole world (UN, 2000). Furthermore, the high water-demand of cotton is criticized. In order to reduce the negative impact on environment and health and to reduce dependency from agro industry, an increasing number of farmers switch to sustainable farming systems. Along with this development goes the establishing of certifying bodies and of intensive marketing-activities to promote “organic cotton” around the world. Organic cotton is presently produced in 23 countries. An increasing awareness of environmental issues resulted into a growing demand for clothes of organic cotton among consumers. Companies integrate more and more organic cotton into their textile program. Worldwide production of organic cotton only amounted to 6,500 tons in the season 2000/2001, a figure that increased to more than 241,697 tons in 2009/2010 (PAN Germany; 2008, Truscott et al., 2010). In 2009/2010, 275,300 farmers grew organic cotton on 461,000 ha. Indian farmers produced 81 % of the total, the share of Egyptian farmers was comparably small with 0.28 % (Truscott et al., 2010). In 1990 (UN, 2000) SEKEM was the first to grow and merchandise organic and biodynamic cotton in Egypt. Elements of organic plant protection methods, developed at SEKEM were taken over by the Egyptian government to be used in integrated cotton cultivation, saving over 30.000 tons of pesticides per annum (PAN Germany, 2005).

In order to minimize environmental pollution, fertilizer-use should meet, not exceed nutrient demand of crops. Therefore, site-specific fertilizing recommendations have to be deduced, taking into account factors like species and variety, farming systems, climatic factors and soil properties. In the middle of last century, investigators stated that the chemical status of soils, as far as plant nutrition with inorganic nutrients is concerned, must be interpreted in terms of soil↔ plant interaction. For this purpose, besides extracting soils with a wide range of chemical solution and determining the nutrient-concentration in the liquid, tissue analyses from parts of the growing plant have to be carried out. Results of soil and plant analysis should be interpreted together in order to give appropriate fertilizer recommendations (Stout and Overstreet, 1950). Tissue analysis as a flexible instrument for estimating the nutritional status of plants was recommended especially for tropical conditions (Fink, 1963). First tissue tests for *Gossypium hirsutum* were carried out in America in 1950 (Joham, 1950). Today, plant analysis is used to diagnose the nutrient status of plants and to guide fertilizer recommendations (Reddy et al., 2000). It is used to evaluate fertilizer practices, to investigate problems of poor growth and to assess the adequacy of fertilization during the growing season (Sabbe and Mackenzie, 1973). The Association of German Agricultural Analytic and Research Institutes proposes the employment of polyelemental plant analysis for agriculture and horticulture in order to estimate nutrient dynamics and control fertilizer application (Breuer et al., 2006).

While world-wide grown *Gossypium hirsutum* is well investigated, for Egyptian *Gossypium barbadense* not much data is available on soil and plant analysis in connection with yield and yield components to be interpreted in terms of nutrient demand and fertilization requirements. This is even more the case for organically grown cotton.

For this reason, objectives of the present study are to

- collect data on the mineral composition of *Gossypium barbadense* cultivars grown in Egypt at a defined growth stadium, on the nutrient status of the corresponding cotton grown soils, and on the yields attained applying fertilizers, soil conditioners and plant strengtheners according to organic respectively biodynamic cultivation standards,
- apply statistical methods to derive an assessment scheme and to evaluate this assessment scheme,
- provide information for optimization of the nutrition of the cotton crop by means of fertilization and others in accordance with the standards of organic farming.

2 State of current research

2.1 Nutrient supply of cotton

Botanically, cotton belongs to the family of *Malvaceae,* the sub-family *Malvoideae* and the genus *Gossypium* (Linné). At least at four different places in the world, cotton was domesticated: in America with the species *Gossypium hirsutum* (synonym G. *vitifolium* LAM.) and *Gossypium barbadense*, in Asia with *Gossypium arboretum* and in Africa with *Gossypium herbaceum*. High-quality *Gossypium barbadense* or "Pima Cotton" exhibits a staple length of >32 mm but represents only 8 % of world's cotton-production. *Gossypium hirsutum*, known as "Upland Cotton" makes up about 90 % of the production (wikipedia, 2010). In Egypt, tetraploid *Gossypium barbadense* varieties are cultivated exclusively. The National Cotton Research Institute is continuously improving the so-called "GIZA"-varieties suitable for the various growing conditions at different sites. The Egyptian Ministry of Agriculture and Land Reclamation is advising farmers to grow only those varieties, which are admitted for the local conditions. *Gossypium barbadense* varieties are also cultivated in the western region of the cotton belt in Arizona, California, New Mexico and West Texas (Unruh and Silvertooth, 1996a).

Cotton *(Gossypium hirsutum)* is classified as salt tolerant, withstanding saline water >5.1 dS/m without yield decrease and semitolerant to boron-concentration in irrigation water between 1 and 2 mg/l (Ayers and Westcot, 1976). Although being a perennial plant, cotton is usually managed as annual crop. It therefore shows an indeterminate fruiting habit: new foliage is continuously produced even after the plant begins to form seeds. The perennial nature of the plant opposes conventional production systems, in which usually high fertilizer input is linked to high yield (Ritchie et al., 2007).

Nutrient uptake by cotton is directly related to dry matter accumulation (Stewart et al., 2003). The initial uptake and growth is slow until first flowers appear after approximately 60 days. The period between 60 and 120 days is characterized by a rapid increase in dry matter production and nutrient uptake (Sabbe and Mackenzie, 1973). Maximum daily accumulation rates for most nutrients occur between early to peak flowering, a period where the rate of root growth is at maximum, too. The uptake of most nutrients precedes the production of dry matter. Therefore an adequate supply of nutrients is needed towards the middle of the growing season to utilize photosynthates and to sustain the production of dry matter by the cotton plant. Redistribution of nutrients occurs after the onset of flowering as nutrients are transported from the leaves and shoots into reproductive tissue (Mullins and Burmester, 2010). Uptake patterns differ according to species and varieties as well as to local conditions. In irrigated areas, cotton grows proportionally even more in the later growth stages than in humid areas (Sabbe and Mackenzie, 1973). Many modern *Gossypium hirsutum* varieties flower early and require readily available supply of nutrients during the fruiting period (Reddy, 2000). This is due to a higher rate of partitioning of dry matter into reproductive tissue, in comparison to older cultivars (Mullins and Burmester, 2010).

At present, 13 elements are considered to be essential for growth for higher plants: nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulfur (S) as macronutrients and boron (B), iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), molybdenum (Mo) and chlorine (Cl) as micronutrients. Elements that are beneficial to some plants but not essential are sodium (Na), cobalt (Co), vanadium (V), selenium (Se), aluminium (Al) and silicon (Si) (Stevens et al., 2002). The elements

Ca, Mg and S are often termed as secondary nutrients, as the plant need for these elements is usually less than for N, P and K.

Tab. 8.1 (Appendix) lists the essential plant nutrients and their physiological function in the cotton plant. While macronutrients are essential not only for metabolism but function as well as main plant constituents, micronutrients are vital for enzyme activity. A high percentage of phloem mobility indicates that nutrients may be retranslocated (partitioned) during plant development in order to furnish generative plant parts with necessary nutrients.

2.1.1 Indicators for nutrient deficiencies in plants

In order to minimize crop loss due to nutrient deficiencies, it is important to understand the function of each nutrient and the way how deficiency will affect metabolism, growth and development. For the farmer it is useful to be aware of indicators for nutrient deficiencies. Possible indicators are deficiency symptoms. Often, deficiency symptoms show first on leaves and are characteristic for a specific nutrient. Visual symptoms in general are the consequences of metabolic disturbances and leaf symptoms are the ones which can be seen at early stages of plant development (Hodges and Constable, 2010). Tab. 8.2 (Appendix) gives an overview of deficiency symptoms of cotton.

Nutrient concentrations in plant parts at a defined state of development are widely used as indicators for nutrient deficiencies. They are representative for the nutrient status of the crop and thus are target values for fertilization that should be attained in order to sufficiently feed the plant. While visual deficiency symptoms may not occur in all cases of deficiency ("hidden deficiency"), nutrient concentrations should indicate non visible (or not early visible) deficiencies. As it is a main topic of the presented work to deduce indicator values for Egyptian cotton *(Gossypium barbadense)*, theory and background of the deduction procedure and interpretation of values will be explained in more detail.

A plant growing under optimum conditions shows predictable nutrient concentrations for the essential elements. A certain element concentration in different plant parts and at different growth stages of the plant mirrors its function in plant metabolism. In case of surplus of one element, this element might be stored in excess in certain plant organs. In case of shortages, relocation is possible for some elements (see Tab. 8.1); partitioning of nutrients between different plant organs is an internal steering-instrument for plant-development. Patterns for distribution and extent of translocation in plants vary for each nutrient, also depending on environment, development status and nutrient status of the plant (Smith and Loneragan, 1997).

The relationship of nutrient concentration and yield respective growth forms the basis of most schemes for interpreting the nutrient status of plants. Fig. 2.1 describes a typical association between yield and macronutrient-concentration in leaves. In this response-curve, the extent of supply with nutrients can be distinguished into severe deficiency, moderate deficiency, luxury range and toxic range. The critical level or critical value is situated between concentrations of moderate deficiency and luxury supply. The C-shape of the left-hand part of the curve, known as the "Steenbjerg-Effect" (Steenbjerg, 1951) is due to the reduced elemental concentration in combination with dry matter reduction under extreme deficiency conditions (Mills and Jones, 1996) and occurs only for macronutrients.

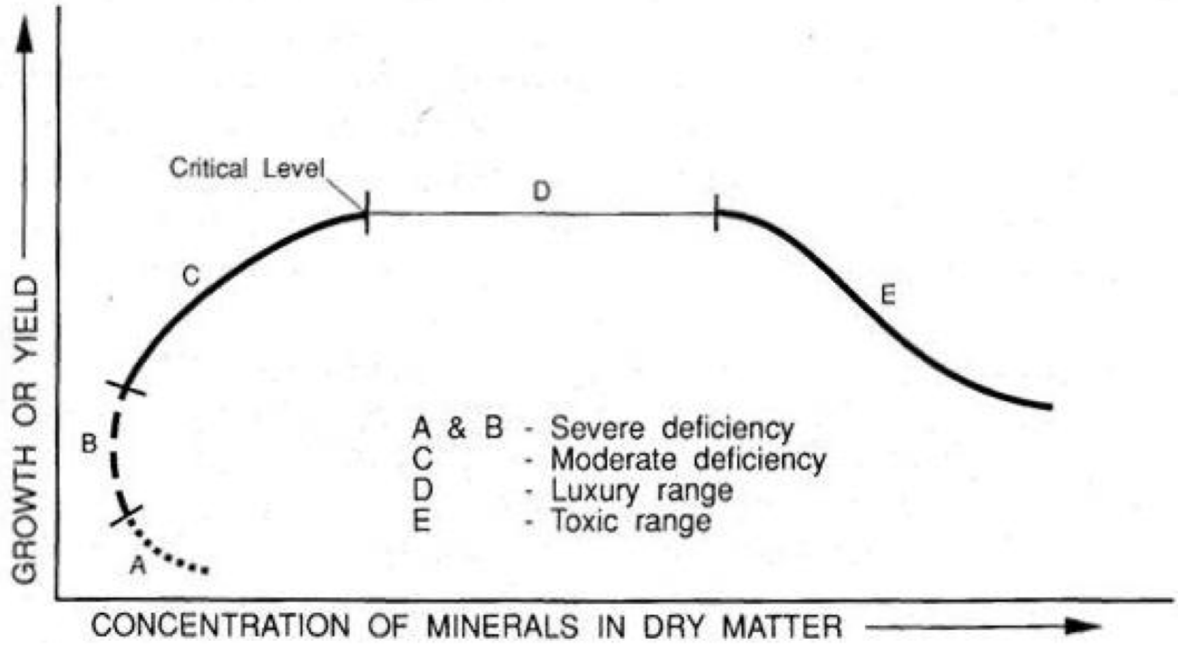


Fig. 2.1: General relationship between yield or plant growth and nutrient concentration according to Smith (1962), cited in Mills and Jones (1996).

Micronutrients characteristically show a different shape of a curve visualizing the relation between element-concentration and yield. Fig. 2.2 visualizes a response-curve for zinc deducted from trials with cotton (*Gossypium hirsutum*), grown in nutrient solution in a greenhouse (Ohki, 1975). The ascending part of the curve is much steeper and there is no Steenbjerg-Effect visible. Yield depression due to toxic effects increase slowly with increasing element-concentration in the plant organ.

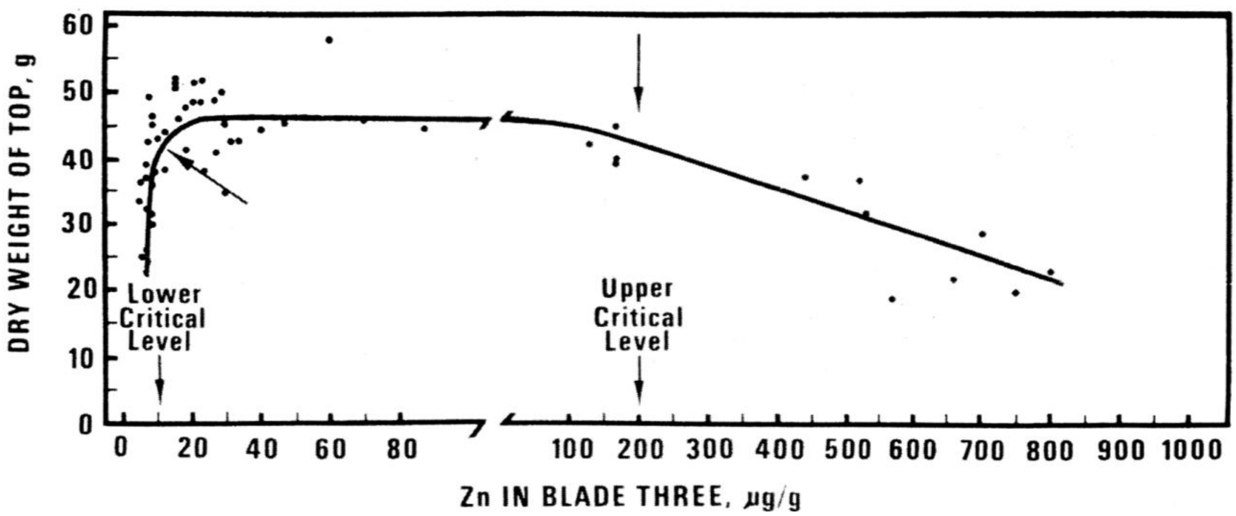


Fig. 2.2: Response-curve for zinc deduced from trials with cotton (*Gossypium hirsutum*), (Ohki, 1975).

Response curves can be deduced by evaluating plant trials or from farm-experiments. In the diagram, yield or growth on the vertical ordinate can be indicated in absolute or relative figures. The element-concentration as dry-matter content is listed on the abscissa.

2.1.2 Definitions of “critical value”

Different definitions exist for the terms critical value or critical level by various authors.

- Originally, the **critical level** was defined as that point where the status of moderate deficiency passes into beginning luxury provision, the point where maximum yield is achieved with the lowest element-concentration (Smith, 1962), cited in (Mills and Jones, 1996).
- Later some authors defined a **lower and an upper critical level**, with a transition zone in between, called **critical nutrient range**. The lower critical level is defined as the element concentration in tissue associated with 10 % growth reduction due to nutrient deficiency and the upper critical level is defined as element concentration in the tissue associated with a 10 % growth reduction due to toxicity (Ohki, 1975; Ulrich and Hills, 1973). Ohki later renamed the lower critical value to **critical deficient level**, the upper critical value to **critical toxic level** (Ohki, 1987, cited in Mills and Jones, 1996).
- Chapman (1967) distinguished between **deficiency range**, **sufficiency range** and **excess range**.
- The **optimal nutrient value** as deduced by Haneklaus and Schnug (1998) is equivalent to the critical level as defined by Smith (1962) and the **optimum yield** as defined by Chapman (1967). The **optimum nutrient range** is defined by the same authors as the range of nutrient concentration which gives 95 % of the yield. This corresponds to the definition of Ohki (1975) and Ulrich and Hills (1973).

The definition of ranges rather than values offers advantages for their interpretation. A hidden deficiency at concentrations below the critical deficient level as well as an indication of excess concentration beyond the upper critical value can be more easily identified (Campbell and Plank, 2000).

Differences in plant parts, stage of growth, genotype and geographical location can cause variations in elemental concentration in the plant (Mills and Jones, 1996), therefore circumstances of the collection of plant material should carefully be logged.

2.1.3 Conditions for cotton plant tissue sampling

Best information on their nutritional status can be obtained with plants being in their maturity. However, information obtained by such analysis can only be used in the following growing season. Usually, tissue tests are dedicated to correct a crop’s nutritional status during the current season. Therefore, sampling time is often placed early during the growing season (Sabbe and Mackenzie, 1973). If cotton samples are taken in early growth stages and readily analyzed, approximately until early flowering, test results can be used to adjust fertilization in the very same season, provided that appropriate fertilization technique is available for mid-season application (i. e. side-dressing, foliar application, fertigation).

Different plant parts are used for carrying out nutrient analysis:

- **Whole plant:** At the beginning of their growth, whole plants are used for nutrient analysis (Sabbe and Mackenzie, 1973). The whole plant is also used to determine nutrient export by a crop (Rochester, 2007).

- **Stems:** The chemical composition of stems is analyzed to explain the process of partitioning of plant nutrients in different plant parts (i.e. Mullins and Burmester, 2010).
- **Petioles:** Petioles are especially suitable to carry out determination of the phloem-mobile nutrients NO_3-N, total P, and total K. Samples should be taken from the most recently matured leaf on the vegetative stem. Petioles should be removed from the leaves at sampling time in order to avoid further transport of nutrients into the leaves. Petiole NO_3-monitoring requires sampling no less than every two weeks during critical development periods, including flowering and fruit development (Campbell and Plank, 2000). Petiole sampling is especially recommended for irrigated cotton cultivation in arid sampling sites. Under these predictable environmental conditions, the detection of transitory nutrients can give information for in-seasonal fertilization. This may be especially important for irrigated cotton as, under these conditions, it usually shows a longer bloom period or even two periods of blooming (Sabbe and Mackenzie, 1973). However, in their 2009 revised recommendation, the North Carolina Department of Agriculture refers to petiole sampling only for the evaluation of soil nitrogen available to the crop. For this purpose, weekly sampling is essential (N.N., 2009). Finally it should be born in mind that petiole nitrate test is sensitive to soil moisture effects (Bell et al., 2003) and factors influencing plant transpiration (Fritschi et al, 2004). High variations of petiole nitrate values over the years are reported (Philips et al., 1987), and Bell et al. (2003) conclude from these findings a limited use of petiole nitrate tests.
- **Leaf blades:** The greatest use of leaf blade analysis is to judge the efficiency of fertilizer use. For this reason, leaf blade analysis should be exercised and evaluated at early vegetation stadium, so producers can correct deficiencies in the same season (Sabbe and Mackenzie, 1973). The uppermost, mature cotton leaf blades on the vegetative stem should be sampled and the petiole be discarded immediately. Sampling period is usually defined as the period of one week before to one week after first bloom (Mitchell and Baker, 2000). Leaf blades have been selected for analysis in sampling sites where the climate is less predictable: nutrient-concentration in leaf blades change less than in petioles due to fluctuations in weather condition (Sabbe and Mackenzie, 1973). Leaf blade samples provide accurate analysis for major elements, secondary elements and micronutrients (N.N., 2009). Concerning the determination of nitrogen, leaf blade analysis are less sensitive to moisture because the residence time of nitrogen in leaf blades is longer than in petioles (Bell et al., 2003).

2.1.4 Critical deficiency levels and sufficiency ranges determined for cotton

Tab. 8.3 and Tab. 8.4 in the Appendix give an overview of critical deficiency values and sufficiency ranges determined for cotton during the last 50 years. In Tab. 8.3, the general set ups for the deduction of the values are listed: as almost all values refer to *Gossypium hirsutum,* the species is indicated only in the two cases where the examined plants belong to another species. In the cases where varieties were named by the authors, these are listed. The table lists the country, where the work was done and whether the values were deduced experimentally or compiled from literature or databanks. Concerning experimental work, a distinction was made between field experiment, on-farm research and the use of nutrient solution in the green house. If noted in the reference, the method, how critical values or sufficiency ranges were deduced from experimental data, is indicated.

It is obvious from the compilation in Tab. 8.4 that many critical values with respect to the metabolism of a single element have been - in the early years - determined in glasshouse experiments, using pot culture or nutrient solution. On the other hand, leaf analysis of cotton is - at least in the US - a routine procedure. Results of analysis of commercially grown cotton certainly has influenced the data published in plant analysis manuals and by the authorities of the southern US (i. e. Mitchell and Baker, 2000), especially as an Information Exchange Group exists on this matter (SEDRA-IEG-6, 2011). Field- and on-farm experiments with the aim to deduce critical values have been conducted until recently. Most data originates from the United States, but some investigations have been carried out in Europe (Greece and Germany), Australia and Africa (Nigeria and Benin), and South America (Brazil). Focal point of most investigation was the supply with nitrogen, followed by potassium and phosphorus. Among the micronutrients, the supply with boron was of special interest, but also Mn, Fe, Cu, and Zn were investigated by different authors. The compilation in Tab. 8.4 clearly shows that critical deficiency levels and sufficiency ranges vary to a great extent, depending on the circumstances of the experiments.

2.1.5 Nutrient concentration of *Gossypium barbadense* and *hirsutum* reported from field experiments

No critical values have yet been deduced for Egyptian *Gossypium barbadense* varieties. In order to have some comparison with concentrations in *Gossypium barbadense* varieties, results of field experiments were checked for nutrient concentrations of plant tissue. Especially in the last two decades, field experiments were conducted in connection with physiological plant tests, cotton quality was examined and also nutrient concentrations in leaves and other plant parts were measured (Tab. 8.5, Appendix). Some of these investigations dealt with or included varieties of *Gossypium barbadense*: El-Sayed et al. (1997) investigated yield response and nutrient concentration of cotton leaves fertilized with potassium and micronutrients, additionally to the regularly farm-practiced fertilization with nitrogen and phosphorus. Nofal et al. (2002) investigated the effect of different combinations and levels of the micronutrients Fe, Mn and Zn on yield components, fibre quality and leaf nutrient content. Kassem and Ahmed (2005) determined N- P- and K-concentrations in relation to level and kind of K-fertilization, Fritschi et al. (2004) investigated in N-uptake and partitioning. Dry matter as well as N-, P- and K- uptake and partitioning were investigated parallel for *Gossypium barbadense* and *hirsutum* by Unruh and Silvertooth (1996a and 1996b).

Surveys on soil and leaf nutrient contents of field crops including cotton were carried out at different sites in the Old and New Land of Egypt during 20 years within an Egypto-German Project "Micronutrients and Plant Nutrition Problems". Nutrient mean concentrations and ranges in cotton leaf blades were determined and compared to sufficiency ranges and critical values compiled from literature for *Gossypium hirsutum* (El-Fouly,1984, Fawzi et al., 1987, El-Fouly and Fawzi, 1996, El-Fouly et al., 1997). Unfortunately, corresponding yield data have not been collected, so critical values and sufficiency ranges for *Gossypium barbadense*-varieties under local, Egyptian conditions could not be established. However, nutrient deficiencies were diagnosed.

Although Tab. 8.5 does not list critical values, it gives at least some impression to what extent nutrient concentrations may differ between the two varieties *Gossypium barbadense* and *Gossypium hirsutum*, as concentrations for the nutrients examined generally have the same dimension.

Examples in Tab. 8.5 show clearly, that nutrient concentration in tissues may increase with higher fertilization rates, for both above mentioned *Gossypium* species and for both, macro- and micronutrients. It shows as well the interdependency between nutrients. Adjustments in the composition of micronutrient also strongly affect composition/uptake of micro- and macronutrients by the cotton plant.

2.1.6 Fertilizer recommendations for conventional cotton cultivation

Concerning conventionally grown cotton, common fertilizer practice includes, beside legume cultivation and the application of manure, mainly the application of mineral nitrogen and phosphorus. In Old and New Land predominating calcareous soils have the ability to fix micronutrients (El-Fouly et al., 1997). Research topics in Egypt concerning the improvement of cotton fertilization mainly deal with balancing of fertilizer dosages according to the physiological needs of the crop. This refers to dosage of the macronutrients nitrogen, phosphorus and potassium as well as the addition of the plant-available micronutrients manganese, iron and zinc.

Furthermore, in recent years, leaf application of P and K during boll-maturation phase was tested in order to overcome a slow release of potassium ions trapped within clay-minerals and of phosphorus fixed as Ca-Phosphate. Tab. 8.5 in the Appendix gives an overview of Egyptian research activities concerning the improvement of cotton fertilization.

2.2 Assessment of critical values

Each evaluation procedure of the nutritional status of plants and soils consists of two main elements: the target value and the evaluation method. Target values can be distinct values (i. e. critical value) or ranges (i. e. sufficiency range).

Scientific publications often deal with methods for the deduction of critical values from a defined set of (soil or plant) data and/or with methods for the evaluation of field data with respect to nutrient deficiencies, using critical values. Emphasis is either laid on critical values or on evaluation methods. Subject of some of the publications is the comparison of methods. Very rarely, publications deal with the resulting fertilization recommendation or even with the evaluation of the given recommendations.

Soil analysis bears a range of disadvantages in comparison to plant analysis (Stout and Overstreet, 1950; Fink, 1963), one reason why critical values for soils are not as common as for plants. To what extent these values are specific for the particular site depends on the extraction methods applied and possibly other factors.

Different methods were developed to determine critical values. Some of these distinguish between groups with different yield performance, in order to deduce critical values from the high yielding subgroup. This is done more or less arbitrary or by means of complicated statistical evaluation. Others are linked to the curvilinear relationship between yield data and mineral composition of plant or soil at an earlier stage of the plant development, known as “nutrient response curve” (Fig. 2.1 and Fig. 2.2). There are graphical as well as mathematical solutions.

2.2.1 Separation of a high yielding subpopulation and calculation of critical values as means of this subpopulation

Different authors use a high yielding subpopulation to derive critical values. There are different rules to be applied for their separation:

In order to exert the DRIS (Diagnosis and Recommendation Integrated System) System, Beaufils and Sumner (1976) devided data on sugar cane grown soils (obtained from the South-African sugar-industy) in a good yielding and a poor yielding population, „drawing a line arbitrarily“ at a certain yield level. Approximately 20 % of all data gathered in this way were allocated to the good yielding population. Target values were calculated as mean values of the good yielding population.

For the evaluation of on-farm experiments with cotton in Benin, Dagbenonbakin (2005) divided data arbitrarily in a high and low yielding population, both of about same size, ensuring that the difference of the two sub-populations of yield was highly significant ($p< 0,001$).

Reference population of another study on Signal Gras (grown in silica with nutrient solution in a greenhouse environment) was formed by chemical analysis of plants showing relative production of dry mass of the plant top of over 50 % of the maximum yield (Silveria et al., 2006).

2.2.2 Separation of the high yielding subpopulation and calculation of critical values using complex statistical procedures

Complex statistical approaches were developed to separate high yielding subpopulation.

Cate and Nelson (1971) published a statistical method for the separation of soil data into different classes. There is a graphical and a mathematical solution. For the graphical approach, a scatter diagram with data on yield and chemical analysis is plotted and a vertical and a horizontal line are used to maximize the number of points in the positive quadrants. This graphical approach aims at maximizing the computed chi-square value representing the test of the null hypothesis that the number of the observations in each of the four quadrants in equal, i. e. the data consist of one random population. For the statistical solution, regression analysis (ANOVA-procedure) is applied: data on chemical analysis and yield are put into ascending order with respect to the analysis data and split into two groups. The corrected sum of squares of deviation from means of the two subpopulations are calculated as well as the total sum of squares of all data and a coefficient of determination (R^2) is set up with these elements for each pair in a sub-group. The division is repeated and the two subgroups producing the highest R^2-value are the ones representing the best separation into two groups. The matching analysis-figure represents the critical value of the total population examined. Thus, the method is using successive tentative levels to ascertain the particular critical level which will maximize overall predictive ability (R^2) with the means of the two groups as predictor values.

In order to separate two groups and indentify a corresponding critical value, Bell et al. (2003) calculated a coefficient of determination (R^2), too, but used a simple linear/quadratic regression.

Minimum target yield and corresponding critical values on the basis of the CND-evaluation method (Parent and Dafir, 1992) were computed using a cumulative variance ratio function $F_i^C(V_X)$ and the chi-square distribution function (Khiari et al., 2001a). The CND nutrient expressions are the row centered ratios of *N-, P-, K-,* and R_d-proportions in tissue samples (see chapter 2.3.3). Variance ratio computation of CND nutrient expressions among two subpopulations arranged in a descending yield order are iterated across population data. A cumulative variance ratio function $F_i^C(V_X) = aY^3 + bY^2 + cY + d$ expresses a cubic relationship with the yield Y. The inflection point marks the point where the curve changes its concavity. It is obtained by deriving twice $F_i^C(V_X)$ and equating it to zero: $\frac{\partial^2 F_i^C(V_X)}{\partial Y^2} = 6aY + 2b = 0.$ The solution for the yield cutoff value is $(-b/3a)$ of the corresponding curve, indicating the separation-point between low- and high-yielding subpopulations. The nutrient-concentrations of the high-yielding population can be used to calculate the CND-norm (critical value). A chi-square cumulative function and the CND r^2 distribution function show a corresponding shape, this is the reason why chi-square possibilities can be calculated. According to the authors, this method is especially suitable for small databases, as they may show local peculiarities, in order to solve nutrient imbalance problems in specific ecological systems. (Khiari et al., 2001b) made exemplary calculations to determine the cut-off point for data for sweet corn.

Beverly (1993) proposed to calculate an efficiency rating, using the percentages of all sufficient samples correctly diagnosed (T^-) and the percentages of all deficient samples correctly diagnosed (T^+). The formula of the efficiency rating is calculated as $[(T^+)/(T^+ + T^-)] \times T^+$. The highest efficiency rating is attained by the critical value. Data from treatments where low yields were a result of over-fertilization (i. e. of nitrogen) were excluded.

2.2.3 Definition of critical values with the aid of curves (graphical) and functions (mathematical)

The nonlinear relationship between growth factors and yield was already postulated by Mitscherlich (1909). He developed the „Law of Diminishing Yield Increments“ – the relation between yield and nutrient supply in soils – from pot experiments. The graphical solution is a nutrient response curve. Later on its mathematical equation was used to explain the relation between yield and other yield factors.

Three decades later, Macy (1936) outlined a theory concerning the relationship between the sufficiency of a nutrient and its concentration in the plant as a measure for the quantitative mineral nutrient supply of plants: The central concept was a critical percentage of each nutrient, above which there is luxury consumption and below which there is poverty adjustment. He explained the critical nutrient composition of a plant as an inherent characteristic, which is probably seldom attained naturally. This ideal composition is representing a balance between the various nutrients and other growth factors. A definition of the critical value as “critical concentration” was given by Tyner (1946) as the concentration (of a nutrient in plant tissue) at which 90 % of the maximum yield is obtained, with respect to the function of the curve, which was usually drawn free hand to best fit the values of a scatter diagram showing yield date and nutrient concentrations (Ware et al., 1982).

Different models for the definition of nutrient response are until present in use.

2.2.4 The Mitscherlich approach

Mitscherlich (1909) expressed with his plant growth model the relation between yield and nutrient supply in soils. According to his experiments, yield response of plants to an increase of a limiting nutrient is proportional to the decrement from the maximum yield attainable (y):

$$dy/dx = \alpha(\beta - y) \qquad (1)$$

In words: the yield response curve for a certain nutrient or growth factor has a definite upper limit and is asymptotic.

For the determination of plant tissue critical value, y stands for plant yield at a tissue nutrient concentration x. β represents the asymptotic maximum yield as x approaches infinity. A is the factor of proportionality.

Under condition that y = 0 (at the beginning of growth, when tissue concentration x = 0) equation (1) can be solved as:

$$y = \beta(1 - e^{-\alpha x}) \qquad (2)$$

As it is more realistic that there is some yield, even at the beginning of plant growth, a parameter γ is introduced:

$$y = \beta(1 - \gamma e^{-\alpha x}) \qquad (3)$$

In order to determine the tissue nutrient concentration associated with 90 % maximum yield, equation (3) is transformed:

$$y/\beta = 1 - \gamma e^{-\alpha x} \text{ with } y/\beta = 0.9 \qquad (4)$$

x as corresponding critical nutrient level can be calculated by transformation of equation (4) as follows:

$$x = -\ln(0.1/\gamma)/\alpha \qquad (5)$$

Cox (1979) used the Mitscherlich model for the determination of critical values for potassium in lupins and Rodrigues (2004) to calculate critical values of petiole-nitrate in potatoes. Ware et al. (1982) applied it for the deduction of critical values for Manganese and zinc in *Gossypium hirsutum*, *Glycine max* and *Sorghum bicolor* (only Manganese). The authors were solving equation (3) by means of a SAS-nonlinear statistical procedure (NLIN). A modified R^2 (1.0-ratio of residual sum of squares to the total corrected sum of squares) was introduced to evaluate the degree of fit for different nonlinear models. The authors point out, that most statistical packages include methods to solve nonlinear equations and thus the Mitscherlich model can be utilized easily, but point out the necessity to carefully check curves for toxicity effects and/or Sternberg effect.

2.2.5 The boundary line approach

Webb (1972) proposed a model for the assessment of crop productivity, in which the performance of the best in the sample examined is taken as a standard against which to judge the remainder, on the assumption that there are reasons other than chance which account for the inferior performance of part of the population. The boundary line approach was based on observations on the relation between the number of achene and the individual berry weight of strawberry (Abbott et al., 1970) respectively the seed number and berry weight of black currant (Webb, 1971). Webb (1972) suggested that this approach is applicable for any biological data sets where one variable is a biological response (e. g. crop yield) to another, independent variable (e. g. nutrient concentration in plant tissue or soil). The upper (or lower) boundary on a plot of the dependent variable (ordinate) against the independent variable (abscissa) represents the limiting response of the dependent variable to the independent variable value, a extent occurs wherever a cause-and-effect relationship between two variables exists.

Webb (1972) recommended the application of the boundary line method to assess reasons for yield deficiencies and to estimate possible yield increases by focussing on all components of yield and by optimizing them.

Concerning the mathematical approach, Heym and Schnug (1995) proposed a 5-step-algorithm to develop a boundary line function:

General definitions: A xy scattered data set S_0 contains N_0 data points:

$$\{x_i^{(0)}, y_i^{(0)}\},\ i = 1, \ldots, N_0$$

S_0 is ordered, with respect to the variable x (= nutrient as independant variable) in ascending order:

$$X_1^{(0)} \leq X_2^{(0)} \leq X_3^{(0)} \leq \ldots \leq X_{Ni}^{(0)}$$

one point of maximum yield y_{MYP} is defined:

$$y_{MYP} > y_i,\ i = 1, \ldots, N_0,\ i \neq i_{MYP}$$

Step 1, identification of outliers by use of the rectangle criterium

Outliers are defined as data points isolated from the main body of the data by (a) the rectangle criterium. This criterium identifies data points as outliers by a distance determined in terms of both, nutrient-concentration and yield. It imposes a net of rectangular cells on the data set. The size of the cells can be chosen freely but can also be varied according to the standard variation of each of the two (depending and non-depending) variables. When the cells are imposed on the scatter-plot, each cell contains at least one data point. If a cell contains less than the number of data points to be selected, the data point in the center of the cell is identified as an outlier.

Step 1a, identification of outliers by use of the circular criterium (complemented by Schnug et al., 1996)

The circular criterium identifies outliers by a radius-like parameter σ. The criterium imposes circular cells with the radius σ on data, normalized as follows:

$$\tilde{x}_i = x_i^{(0)} / max\{x_i^{(0)},\ i = 1, \ldots, N_0\}$$

$$\tilde{x}_i = y_i^{(0)} / max\{y_i^{(0)},\ i = 1, \ldots, N_0\}$$

Each data point is centered within its own cell, so that each cell contains at least one data point. If a cell contains less than a given number N_{cell} of data points, the data point in the center is identified as an outlier.

The reduced data set S_1 is obtained, with $N_1 = N_0 - N_{out}$, $0 \leq N_{out} \leq N_0$ data points.

Step 2, classification

If a third variable (i. e. clay content) is of significant influence for the yield response, this is visible as two or more distinct clouds of data points in the scatter plot. Data should - in this case - be categorized in relation to this variable(s).

Step 3, upper boundary step function

This function s(x) is constructed as approximation for the upper boundary line. A data set S_2 is built from S_1 by applying the transformation rules on all data points $\{x_i^{(1)}, y_i^{(1)}\}$, i = 1, …..,N_1:

$$x_i^{(2)} = x_i^{(1)} \text{ for } i = 1, \ldots, N_1$$

$$y_i^{(2)} = y_i^{(1)}$$

$$x_i^{(2)} = x_i^{(1)} \text{ for } i = 1, \ldots, N_1$$

$$y_i^{(2)} = y_i^{(1)}$$

$$y_{i+1}^{(2)} = \begin{cases} y_i^{(2)} & \text{if } y_{i+1}^{(1)} < y_i^{(2)} \\ y_{i+1}^{(1)} & \text{if } y_{i+1}^{(1)} \geq y_i^{(2)} \end{cases} \quad \text{and } 1 \leq i \leq i_{MYP}-1$$

$$y_{i-1}^{(2)} = \begin{cases} y_i^{(2)} & \text{if } y_{i-1}^{(1)} < y_i^{(2)} \\ y_{i-1}^{(1)} & \text{if } y_{i-1}^{(1)} \geq y_i^{(2)} \end{cases} \quad \text{and } i_{MYP}+2 \leq I \leq N_1$$

$$Y_{N1}^{(2)} = y_{N1}^{(1)}$$

Each data point is lifted with respect to its left (right) neighbor if the index is smaller (greater) than the index i_{MYP} of the maximum yield position. The upper boundary step function s(x) is constant for each of its sub-functions in terms of data set S_2 as listed below:

$$s(x) = \begin{cases} 0 & \text{for } x < x_1^{(2)} \\ y_i^{(2)} & \text{for } x_i^{(2)} \leq x \leq x_{i+1}^{(2)} \text{ and } 1 \leq I < i_{MPY} \\ y_{MPY} & \text{for } x = x_{MPY}^{(2)} \\ y_{i+1}^{(2)} & \text{for } x_i^{(2)} \leq x \leq x_{i+1}^{(2)} \text{ and } i_{MPY} \leq I < 1 \\ 0 & \text{for } x > x_{N2}^{(2)} \end{cases}$$

Step 4, upper boundary line-function (u)x

A polynomial $p_N(x) = \sum_{i=0}^{N} a_i x_i$, which is a function of x only, possesses a 2nd derivate with respect to the nutrient variable x and is continuous for $x_1^{(2)} \leq x \leq x_{N2}^{(2)}$ is suitable, according to the authors, to interpret the boundary line function. Heym and Schnug (1995) proposed a polynomial of 4th order to characterize the upper boundary line:

$$p_4(x) = a_0 + a_1x + a_2x^2 + a_3x^3\ a_4x^4$$

The authors propose to fit the polynomial to data set S_2 according to the least square method.

$$U(x) = \begin{cases} p_4(x) & \text{for } x_i^{(2)} \leq x \leq x_{N2}^{(2)} \\ 0 & \text{else} \end{cases}$$

With $a_i = a_i(x_j^{(2)}, y_j^{(2)}), N_2)$ with $i = 0,\ldots,4$ and $j = 1,\ldots.N_2$, depending implicitly on data set S_2.

Step 5, optimum values and optimum ranges

The optimum nutrient level (i. e. sufficiency level) is determined by the zeros of the first derivative of the upper boundary line and the sign of the second derivative at this point:

$$u'(x_{opt}) = 0,\ u''(x_{opt}) < 0$$

Along with the definition of a critical yield (i.e. at 95 % of the maximum yield) goes the definition of x_l and x_h as low (left) and high (right) endpoints of the sufficiency level, which are calculated by

$$u(x_{l,h}) - 0{,}95 * y_{opt} = 0$$

The Boundary Line Development System (BOLIDES) has, in the above described form, been applied to determine critical nutrient values for sugar beet (soil and plant tissue) (Haneklaus and Schnug, 1998), oilseed rape and cereals (Schnug and Haneklaus, 2008).

Schmidt, et al. (2000) used the boundary line approach to analyze N_2O-flux from agricultural soils. The methodical approach differs from the one introduced by Heym and Schnug (1995) in the following points: No outliers are eliminated before the deduction of the boundary line. The boundary line is constructed by calculating boundary points. For this aim, the independent variables on the x-axis are devided into segments. For each segment, the dependent variables (data-values of the y-axis) are aggregated by calculating a 99 %-percentile. These 99 %-percentiles were taken as boundary points and suitable curves were fitted in.

Blanco-Macias et al. (2009) calculated nutrient standards for an *Opuntia sp*. by applying the boundary line approach. These authors eliminated obvious outliers manually, then, in a second step, devided the independent variables into segments and selected only the highest point of each segment. The result is a scatter-diagram of the best performers. In a third step, a second degree polynomial function is fitted.

Straight lines instead of curves were used to construct a boundary line by several authors, too.

Walworth et al. (1985) used the boundary line approach to define plant tissue optima of *Zea mays* L. and stated, that boundary lines describe yields that may occur under a given set of conditions. According to the authors, the intersection of two straight lines, which can be fitted to the upper boundary of a plot of yield data versus data on nutrient concentrations as regression lines, mark the critical value of the crop investigated.

Evanylo and Sumner (1987) employed the boundary line approach for the development of soil nutrient norms for soybean production by dividing data according to soil characteristics and plotting yield versus nutrient-concentration in soils. Soil norms were deduced from the date according to Walworth et al. (1985), but the range of all soil data analysed was presented as well for coarse and fine soils, respectively.

Casanova et al. (1999 and 2002) modified the boundary line approach in order to interpret yield depressions in relation to soil properties with the help of data from field experiments. The authors used a straight line describing the highest yields observed over the range of soil property values measured.

Poovarodom and Chatupote (2002) used the approach proposed by Walworth et al. (1985) to specify durian nutrient standards in Thailand. They could clearly identify a characteristic triangular pattern for the relation of yield and most nutrients for high yielding orchards. This pattern was not obvious for the relation of yield and Fe, Mn (and the relations Mg/Ca and Zn/P). The authors used the intersection of regression lines with a positive slope and a relative yield of 60, 80 and 100 % to define the maximum value for low, deficient and optimal sufficiency range categories.

Mc Cray et al. (2010a) applied straight boundary lines for the definition of production limits of sugarcane at leaf nutrient conditions less than optimum. Linear regression was used to define lines with selected boundary points. More precise nonlinear regressions were considered beyond the scope of the project. The authors defined categories of < 75, 75-89, 90-99 % and not limiting yield in relative tons cane/ha and related the number of findings for each nutrient to the four categories, for soils with high and low organic matter concentration respectively, thus they identified the most limiting nutrients in both soil groups.

The Environmental-Department of the Rothamsted Research Institute (2010) presented some results of own researches on the boundary line method. They report on two main issues of criticism towards this method: (1.) the lack of evidence that dependent and independent variables are genuinely bounded and (2.) the need of a repeatable and objective method to model the boundary line. Methods are presented to evaluate the strength of evidence for the presence of a boundary. One method tests the hypothesis that a higher density of points is expected in the region of the boundary than could be seen if the data were from a bivariate normal distribution. Another method compares the boundary model to an unbounded model (Milne et al., 2006a). A boundary modelling program is offered which attempts to fit a censored probability distribution to a given data set by maximizing the likelihood function. Guidelines are given how to use the program and how to prepare the data set (Milne et al., 2006b).

2.3 Evaluation of individual plant- and soil data

In case of the availability of target values for soil or plant parameters, individual results of analysis can to be compared to these targets. The results of this kind of evaluations undertaken are, in general, categorizations of plant nutrients according to their scarcity respectively their abundance. In a last step, a fertilization concept can be deduced from the results of the evaluations.

Different methods, aiming at the comparison of individual data on soil or plant analysis with target values have been developed, presented and discussed. These methods can roughly be devided into univariate, bivariate, and trivariate approaches, depending on whether the analysed nutrient value in question is compared to one target value, to target values of the other elements analysed, one by one or to all target values of the elements analysed at one time.

2.3.1 Univariate approach: i. e. Professional Interpretation Program for Plant Analysis (PIPPA)

The univariate approach interprets the “Law of the Minimum”, first articulated by Liebig (1855) and based on the work of Sprengler (1828). This law states, that, at any time, the growth of plants is limited by only one single resource. It is popularly illustrated by a barrel filled with water, constructed out of stanchions of different length and representing the different growth factors respectively nutrients: the water-holding capacity of the barrel is limited by the shortest stanchion, representing the factor or nutrient most limiting plant growth. The univariate approach also considers the “Law of Diminishing Yield Increments” (Mitscherlich, 1909).

The program PIPPA makes use of the Boundary Line Development System (BOLIDES) for the evaluation of plant analysis data of oilseed rape, cereals and sugar beet crops for the macronutrients N, P, S, K, Ca, Mg as well as the micronutrients Fe, Mn, Zn, Cu, Cl, B and Mo (Schnug, 1990; Schnug and Haneklaus, 1992; Schnug and Haneklaus, 2008a).

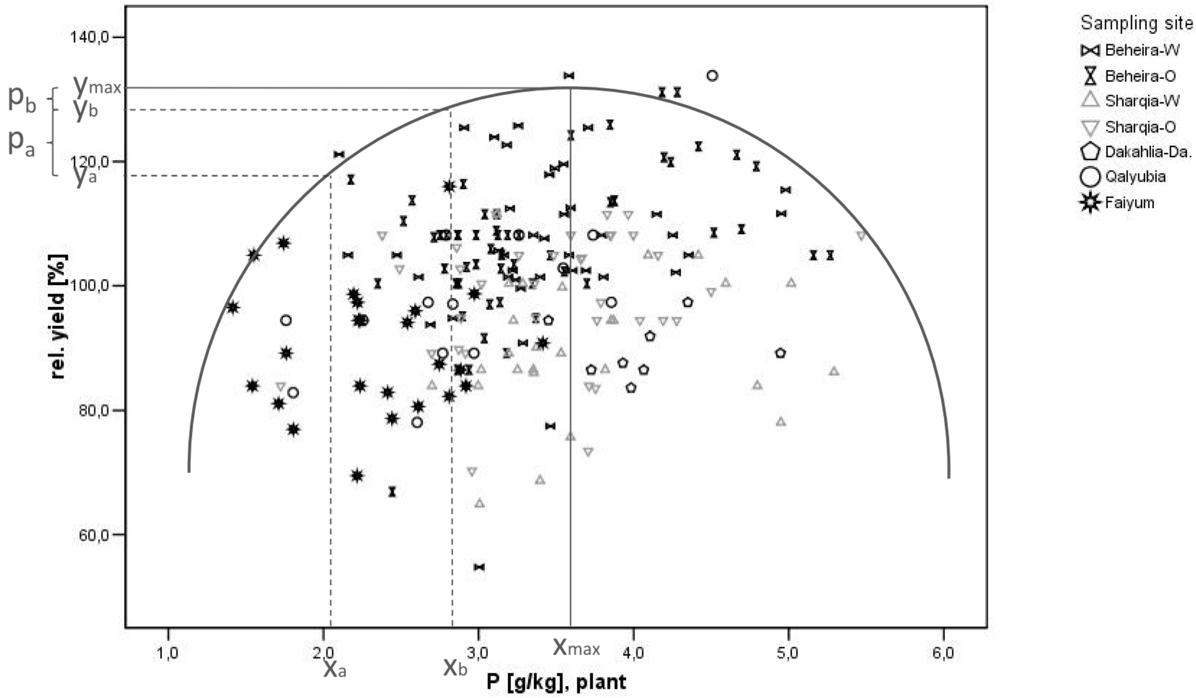


Fig. 2.3: Principle of the evaluation of data of plant analyses with PIPPA (x_a=value of plant tissue analysis, y_a= value for corresponding yield according to BOLIDES, y_{max}-y_b=potential of yield increase).

The program compares element by element the yield potential deduced from the individual data analysis by use of the boundary line approach with the maximum yield. For this purpose the individual values of the data are inserted into the functions obtained with BOLIDES in order to calculate the individual yield potential. The gap between maximum yield and individual yield potential visualizes the degree of deficiency for this element (Fig. 2.3). PIPPA therefore acknowledges Mitscherlich’s “Law of Diminishing Yield Increments” (Mitscherlich, 1909).

The program lists the results for all tested plant nutrient concentrations of one sample in relative order of their scarcity, referring to Liebig’s “Law of the Minimum” (Liebig, 1855).

The source code of PIPPA is listed in (Schnug and Haneklaus, 2008a) and the DOS-version of the program is available (Schnug and Haneklaus, 2008b).

2.3.2 Bivariate approach, i. e. Diagnosis and Recommendation Integrated System (DRIS)

Bivariate approaches consider the existence of optimal chemical compositions of plants due to the different physiological functions of plant nutrients. Nutrient concentrations generally change with plant age and are influenced by translocation processes during plant-maturation (see also chapter 2.1.1). As the chemical composition of plant organs at certain stages of development characterize the nutritional status of plants, element ratios are taken as target for the evaluation of plant nutritional status.

The use of ratios of two essential elements in order to evaluate the plants´ nutritional status recognizes the interdependency of these elements. This can be categorized as a simple, bivariate approach. A commonly used ratio is N:S, ideally being between 10 and 15. As the N:S ratio approaches and exceeds 18, sulfur is limited in relation to nitrogen, because of an inhibition of N-assimilation due to lacking S. Other ratios commonly used to support sufficiency range interpretations include N:K (between 1.2 and 2.2) and Fe:Mn (> 1)(Campbell and Plank, 2000).

A more complex bivariate approach, the Diagnostic Recommendation Integrated System (DRIS), has been developed by South-African scientists around Beaufils, using mass data on soil and plant analysis of sugar cane (Beaufils, 1973; Beaufils and Sumner, 1976; Walworth and Sumner 1987). It places emphasis on the ratios of concentrations of essential elements, not on their absolute concentrations. The DRIS evaluation compares ratios of nutrients in a representative sample with the mean ratios of these elements in high yielding populations (Campbell and Plank, 2000). A nutrient index X is calculated as follows:

$$Xindex = \frac{\Sigma\left[f\left(\frac{X}{A}\right)\frac{k}{CV_{\left(\frac{X}{A}\right)}}+f\left(\frac{X}{B}\right)\frac{k}{CV_{\left(\frac{X}{B}\right)}}\ldots+f\left(\frac{X}{Z}\right)\frac{k}{CV_{\left(\frac{X}{Z}\right)}}\right]-\Sigma\left[f\left(\frac{a}{X}\right)\frac{k}{CV_{\left(\frac{a}{X}\right)}}+f\left(\frac{b}{X}\right)\frac{k}{CV_{\left(\frac{b}{X}\right)}}\ldots+f\left(\frac{z}{X}\right)\frac{k}{CV_{\left(\frac{z}{X}\right)}}\right]}{n+m}$$

A, B, C, …Z and a, b, c,…z : nutrient-concentration or any other factor influencing yield or quality

In case that $(X/A) > (\overline{X/A})$ or $(a/X) > (\overline{a/X})$,

$f\left(\frac{X}{A}\right) = 100\left[\frac{(X/A)}{(\overline{X/A})} - 1\right]$ and $f\left(\frac{a}{X}\right) = 100\left[\frac{(a/X)}{(\overline{a/X})} - 1\right]$

In case that $(X/A) < (\overline{X/A})$ or $(a/X) < (\overline{a/X})$,

$f\left(\frac{X}{A}\right) = 100\left[1 - \frac{(\overline{X/A})}{(X/A)}\right]$ and $f\left(\frac{a}{X}\right) = 100\left[1 - \frac{(\overline{a/X})}{(a/X)}\right]$

In case that $(X/A) = (\overline{X/A})$ or $(a/X) = (\overline{a/X})$,

$f\left(\frac{X}{A}\right) = 0$ and $f\left(\frac{a}{X}\right) = 0$

$CV_{(X/A)}$ and $CV_{(a/X)}$: coefficients of variations found for X/A or a/X in a reference population

k: sensitivity coefficient, arbitrarily chosen

The concentration of *X* in a sample is set in relation to the concentration of all other elements analysed, each single value being weighted by multiplication with the reciprocal coefficient of variations, the same is done for the reference population. The values of the sample and of the reference-value are subtracted from each other.

DRIS-indices are to be interpreted as follows: (1) The optimum is indicated by a DRIS-value of zero. The further an index lies from zero (in negative or positive direction), the less is the chance of recording a high yield. (2) A low yield can be obtained when an index is near zero, because another factor limits yield. (3) The higher the yield, the smaller is the deviation of concentration acceptable in the plant (or soil) (Beaufils and Sumner, 1978).

An order of (fertilizer) nutrient-requirement for an individual analysis (or a group of performers) can be deduced from the value and of the sign (positive or negative) of the indices (Sumner and Beaufils, 1975).

A simplified formula for the original DRIS-approach was published by Walworth and Sumner (1987).

$$Index_A = f\left(\frac{A}{B}\right) + f\left(\frac{A}{C}\right) + f\left(\frac{A}{D}\right) + \cdots . + f\left(\frac{A}{N}\right)$$

$$Index_B = f\left(\frac{A}{B}\right) + f\left(\frac{B}{C}\right) + f\left(\frac{B}{D}\right) + \cdots . + f\left(\frac{B}{N}\right)$$

….

$$Index_N = f\left(\frac{N}{B}\right) + f\left(\frac{N}{C}\right) + f\left(\frac{N}{D}\right) + \cdots . + f\left(\frac{N}{M}\right)$$

with $f\left(\frac{A}{B}\right) = \left[\frac{\left(\frac{A}{B}\right)}{\left(\frac{a}{b}\right)} - 1\right] * \frac{1000}{CV}$ for $\frac{A}{B} \geq \frac{a}{b}$

and $f\left(\frac{A}{B}\right) = \left[1 - \frac{\left(\frac{A}{B}\right)}{\left(\frac{a}{b}\right)}\right] * \frac{1000}{CV}$ when $\frac{A}{B} < \frac{a}{b}$

$\frac{A}{B}$: value of the ratio of two of the elements analysed

$\frac{a}{b}$: value of the corresponding norms

Z: number of functions

CV: coefficient of variation found in a reference population and associated with the nutrient ratio norms $\frac{a}{b}$ to $\frac{a}{n}$

This formula has been used for the programming of computer applications running in EXCEL (Antolin, 2007) and Foxpro 6 (Selvaradjou et al., 2005).

The system results in a ranking of elements in their order of limitedness.

Antolin (2007) interprets DRIS Indices as follows:

$|I_A|$: absolute value of $Index_A$

NBI_A: average nutrient balance index, $\left(\frac{\sum |I_A|}{n},\ \ n = number\ of\ data\ for\ nutrient\ value\ A\right)$

For $Index_A > 0$

$|I_A| > NBI_A$: excess

$|I_A| \leq NBI_A$: adequate

For $Index_A < 0$

$|I_A| > NI_A$: deficient

$|I_A| \leq NBI_A$: adequate

DRIS norms are widely applied to evaluate plant tissue analysis and soil analysis for a large range of crops: cotton, maize, sorghum peanut and yam (Dagbenonbakin, 2005), signal grass (Silveria, et al., 2006), sugarcane (Anjos Reis and Monnerat, 2003; McCray et al., 2010b) fruit trees (Alves Mourão Filho, 2004, review). Sumner and Beaufils (1975) stated, that an improved sensitivity for diagnosis can be achieved at any stage of plant development and irrespective of moisture status, season and variety.

Evanylo and Sumner (1987) and Evanylo (1990) reported the successful application of the boundary line method for the development of soil and plant diagnostic DRIS norms.

A modified Diagnosis and Recommendation Integrated System (MDRIS) was proposed by Elwali and Gascho (1984). In this system, the yield was included as one of the nutrient parameters and was attached to the denominator of the expression for the calculation of functions to determine indices. For MDRIS, a computer application for the calculation of indices and running in Foxpro 6 is also available (Selvaradjou et al., 2005).

2.3.3 Trivariate approach: the Compositional Nutrient Diagnosis (CND)

Based on the principles of compositional data analysis (CDA), Parent and Dafir (1992) presented in 1992 the Compositional Nutrient Diagnosis concept. CND recognizes the interdependence of nutrient concentrations in plants, as the sum of all dry-matter-concentrations always totals up to 100 %, or, interpreted in another way, sums up to 1. The linearization by "row centred log rationing" of nutrient fractions is used for multivariate diagnosis and principle component analysis of data. CND takes all possible nutrient interactions into account. Nutrient indices are composed of two separate functions, one considering differences between nutrient levels, another examining differences between nutrient balances of the individual plant and target values.

Calculation steps for CND-evaluation in detail are as explained below (Parent and Dafir, 1992; Khiari, et al., 2001a).

Plant tissue composition forms a *d*-dimensional nutrient arrangement S^d of *d+1* nutrient proportions (*d* nutrients and a filling value R_d):

$$S^d = [(N, P, K, \ldots, R_d): N>0, P>0, K>0, \ldots R_d>0, N + P + K + \quad + R_d = 100]$$

100: total dry matter concentration *(%)*

N, P, K: nutrient proportions of dry matter concentration *(%)*

R_d: filling value; $R_d = 100 - (N + P + K + ...)$

G: geometric mean of *d+1* nutrient proportion components (including R_d); $G = \sqrt[d+1]{N\,x\,P\,x\,K\ \ldots .\ R_d}$

Row-centered log ratios V_X for the nutrient X are set up for each nutrient considered, including R_d:

$$V_N = ln\left(\frac{N}{G}\right),\ V_P = ln\left(\frac{P}{G}\right),\ V_K = ln\left(\frac{K}{G}\right), \ldots \ldots\ V_{R_d} = ln\left(\frac{R_d}{G}\right)$$

The sum of all row-centered log ratios including the filling value must equal zero:

$$V_N + V_P + V_K + \ldots.. + V_{R_d} = 0$$

$V_N^*, V_P^*, V_K^*, \ldots, V_{R_d}^*$: means of row-centered log rations of *d* nutrients = CND-norms

$SD_N^*, SD_P^*, SD_K^*, \ldots, SD_{R_d}^*$: standard deviations of *d* nutrients

Independent plant speciments are assigned to individual row-centered log ratios as follows to form CND-indices:

$$I_N = \frac{(V_N - V_N^*)}{SD_N^*};\ I_P = \frac{(V_P - V_P^*)}{SD_P^*};\ I_K = \frac{(V_K - V_K^*)}{SD_K^*};\ \ldots.;\ I_{R_d} = \frac{(V_{R_d} - V_{R_d}^*)}{SD_{R_d}^*}$$

CND-indices describe standardizations and linearized variables in a *d+1* dimensional space.

The CND nutrient imbalance index of a plant sample investigated is its CND r^2, which can be described as follows:

$$r^2 = I_N^2 + I_P^2 + I_K^2 + \cdots + I_{R_d}^2$$

The closer r^2 to zero, the higher is the probability of obtaining a high yield. r^2 has a chi-square distribution with *d+1* degrees of freedom.

CND-evaluations were carried out exemplarily for checking the nutritional status of potatoes (Khiari et al., 2001c) and sweet corn (Khiari et al., 2001b).

A computerized CND-evaluation, running in Foxpro 6, is available (Selvaradjou et al., 2005).

3 Materials and methods

3.1 Origin of samples

Plant- and soil samples were taken in the three successive years 2008, 2009 and 2010 from fields of cotton-suppliers of NATURETEX, one of the enterprises of SEKEM-holding. These farms were partly certified according to the demeter-standard by COAE (Centre of Organic Agriculture in Egypt) (COAE, 2011). Non-biodynamic working farms were cultivating cotton organically according to ECOA (Egyptian Centre for Organic Agriculture)-standards (ECOA, 2010). In 2010, GPS data of the sampling positions were collected from all farms involved in the survey.

Tab. 8.7 (Appendix) lists the names of the farm-owners, district and governorate and GPS-coordinates of the farms and indicates, whether the farm is operated according to the standard of demeter or organic agriculture. Altogether, 207 data sets (soil- and plant composition, yield) could be composed from 74 data sets of 2008, 68 of 2009 and 65 samples of 2010.

Fig. 3.1 gives an overview of the geographical positions of the sampling sites: farms in the governorate Beheira in the northwest of the delta are marked blue, farms in the governorate Sharqia in the south east of the delta are marked red, farms in the governorate Qalyubia in the southern delta are marked in orange and the farms situated in Faiyum are marked in yellow.

Farmers were questioned concerning their fertilizing habits and irrigation practices. Additionally, recommendations concerning the use of fertilizers and the availability of irrigation water were obtained by EBDA (Egyptian biodynamic association)- and NATURETEX-extension staff.

The GIZA-cotton variety stipulated by the authorities to be used in the region was also noted. Growth stage as well as growth habit were recorded for each field visited. Farmers and working staff were asked for the crop rotation scheme. Farmers who run their farms according to biodynamic criteria were asked whether they had received the preparations from the EBDA-extension service and how many foliar applications they have conducted.

Tab. 8.8 to Tab. 8.11 show exemplarily crop-rotation systems with cotton in the different governorates. Generally, 3 year rotations were exercised, but a 2 year-rotation was also practiced (Dakahlia). Whereas extension advice includes the application of phosphorus (as rock phosphate), potassium (as feldspar) and sulfur (as elemental sulfur), the use of these fertilizers was not common, either due to a shortage of the products or as a result of the general unfavorable economic situation. In order to overcome severe nutrient deficiencies and to increase the input of phosphate and potassium into soil, the compost used was often upgraded with an input of 10 % chicken or pigeon manure (Bordeny, 2010).

3.2 Sampling procedures and sample preparation

Cotton-fields were sampled when plants were showing between 5 and 9 fruiting branches. Development was between “candle-stage of bud-development” and “appearance of first bolls” (Ritchie et al., 2007). This variability was, on the one hand, due to slightly different climatic conditions in the governorates and the different GIZA-varieties used at these sites, on the other hand due to individual influences, such as different sowing dates and land cultivation practices, including fertilization.

Indication of sampling-regions (governorates): blue=Beheira, red=Sharqia, green=Damietta, Dakahlia, orange=Qalyubia, yellow=Faiyum

Fig. 3.1: Sampling sites of organically grown cotton in Egypt sampled in 2008 to 2010.

A part of the field which appeared homogenous and representative for the growth of the entire field was chosen and a square of 4 m side-length was defined.

Fig. 3.2: Measuring the size of one sampling plot of organically grown cotton in Egypt.

20 to 50 leaf-blades are collected from individual plants inside this square, amounting to at least 200 g fresh leaves making up to approximately 20 g of dry matter. The youngest, but fully differentiated main stem leaves from the top of the plants were collected without petioles. Paper bags were used for sampling.

Fig. 3.3: Sampling young, fully matured main stem leaves from organically grown cotton in Egypt.

The leaves were dried in a greenhouse usually used for drying herbs grown at SEKEM Farm. For drying, leaves were spread on a clean sheet of paper on drying racks, and - in order to avoid contamination with dust - covered with another clean sheet of paper until dry and crispy, usually for 48 hours.

Fig. 3.4: Air drying of leaves of organically grown Egyptian cotton in a drying rack.

In the fields, the collected leaves were more or less covered with dust. In general, leaves therefore were cleaned with a dry, clean cotton cloth. As the sampled plant-material usually had lost turgor when reaching the drying facilities, washing or rinsing the leaf-surface was omitted in order to avoid loss of water-soluble plant-nutrients.

Fig. 3.5: Soil samples of organically grown cotton fields in Egypt after being dried and sieved.

After drying, the leaf material was milled in blenders and stored dry in plastic bags. In this condition the samples were packed and sent to the laboratories of the Institute of Crop and Soil Science at Federal Research Center for Cultivated Plants (JKI) in Braunschweig.

Together with the plant-sampling, samples of soil were taken from the same square of 4 m side-length. The samples consisted of at least 10 subsamples distributed over the entire 4 m-plot. The sampling depth was around 10 to 20 cm. Paper bags were used for sampling. For drying, soil samples were transferred to the foliar green-house, spread on drying racks, lined with clean sheets of paper and covered with clean sheets of paper, too. The air-drying usually took 48 hours. The dry samples were gently crushed and passed through a 2-mm mesh sieve. In this condition, samples of each 50 g were shipped to the JKI-laboratory in Braunschweig.

Yields from the different farms were obtained from NATURETEX-records. Total weight of all cotton produced (seeds and fibers, all qualities) was measured at governmental collecting facilities in kilogram and, in 2008 and 2009, transferred to the traditional Egyptian unit “quintar”, which equals 157.5 kg. In 2010, yield-data were also recorded in the unit “kg”. NATURETEX remunerates the entire harvest, which composes of cotton from three picking dates. Only cotton of the first two pickings usually is processed, as cotton of the 3rd picking often is of inferior quality. There is a central collection point in every governorate. A governmental quality manager is evaluating each delivery.

3.3 Chemical methods

3.3.1 Soil analysis of main chemical properties

Soils were analyzed according to the methods compiled in Tab. 3.1.

The utilization of composted animal manure as soil conditioner and fertilizer is one main component of organic agriculture. So as to evaluate soil quality of the individual sites, it is particularly useful to determine soil organic matter content. A standard method is the determination of carbon concentration by dry oxidation at high temperature (i. e. 1,200 °C with Elemental analyser vario MAX CNS), followed by catchment and titration of the generated CO_2. Conversion into organic matter content is done by using the factor 1,724, which represents the mean C concentration in soil organic matter (Scheffer et al., 1984). For $CaCO_3$-rich soils, the above method leads to misinterpretation, as much of the oxidized CO_2 derives from carbonates (Purzner, 2008). This is the case in some of the investigated soils, i. e. at the Beheira governorate, where C_{total}-concentrations, determined by dry oxidation, were elevated and exhibited a high variability (Fig. 8.3, Appendix). Fig. 3.6 visualizes, that a great share of the carbon detected by dry oxidation is not of organic origin but derives from carbonates: the histogram relates the concentration of C_{total} detected in Egyptian alluvial soils to visible occurance of soil carbonates, like sea shells, grouped for the different sampling sites.

High mean values for C_{total} in Beheira-W (3.17 %) and in Beheira-O (2.69 %) are related to a marked content of visible carbonates. On the other hand, small mean values for C and small standard deviations seem to go along with a dark soil colour and the absence of visible carbonate particles. This is the case for Sharqia-W (1.58 %), Sharqia-O (1.08 %), Dakahlia/Damietta (1.70 %) and Qalyubia (1.59 %). Faiyum exhibits an elevated concentration of C_{total} (1.91 %), without showing visible carbonates (see also Fig. 3.7 to Fig. 3.9).

As an alternative method for the determination of the organic carbon concentration, in the soil samples of 2009 and 2010 organic carbon was determined colorimetrically by detecting humic acids in a Westerhoff extract as proposed by Haneklaus and Schnug (1996). Values obtained by this method were low - in comparison to soil analysis data from literature (Klages and Schnug, 2012a).

Tab. 3.1: Soil analytical methods employed at the Institute for Crop and Soil Science, Julius Kühn-Institute, Braunschweig, Germany.

Parameter	Dimension	Extracting agent	Extraction method (reference)	Analytical method (reference)
Texture				sensoric (Durner, 2008) (DIN ISO 11277, 2002-08)
Conductivity	µS/cm, 25°C	1+10 (m+V) soil+water suspension (deionised water)	(VDLUFA, 2009)	specific electrical conductivity (VDLUFA, 2009)
pH-value		1+2,5 soil+$CaCl_2$-suspension	(DIN ISO 10390, 2005; VDLUFA, 2004b)	(DIN ISO 10390, 2005)
N_{total}	%	none	Elemental analyser	vario MAX CNS
C_{total}	%	none	Elemental analyser	vario MAX CNS
Humic acids, Cu_{West}, Zn_{West}	mg/kg	0,43M HNO_3 (Westerhoff)	(Haneklaus and Schnug, 1996)	photometric (430 nm), (Haneklaus and Schnug, 1996)
P_{H2O}, Na	g/kg	water	(Van der Paauw, et al., 1971)	photometric (John, 1970)
P_{CAL}	g/kg	Calcium Acetate Lactate (CAL)	(Schüller, 1969)	photometric (Murphy and Riley, 1962)
P_{Olsen}	g/kg	$NaHCO_3$	(Olsen et al., 1954)	photometric (Murphy and Riley, 1962)
K_{CAL}	g/kg	Calcium Acetate Lactate (CAL)	(Schüller, 1969)	photometric (Murphy and Riley, 1962)
$Mg_{Schachtschabel}$	g/kg	0.0125M $CaCl_2$	(Schachtschabel, 1954)	Atomic Absorption Spectroscopy (AAS)/Inductively coupled Plasma Emission Spectrometry (ICP-OES)
P_{LE}, K_{LE}, Ca_{LE}, Mg_{LE}, S_{LE},	g/kg	AAAc (Acid Ammonium Acetate)-EDTA (Ethylenediaminetetra-acetic acid) solution	(Lakanen and Erviö, 1971, Sillanpää, 1990)	Optical Emission Spectrometry (ICP)
B_{LE}, Fe_{LE}, Mn_{LE}, Cu_{LE}, Zn_{LE}, Mo_{LE}, Al_{LE}	mg/kg	AAAc (Acid Ammonium Acetate)-EDTA (Ethylenediaminetetraacetic acid) solution	(Lakanen and Erviö, 1971, Sillanpää, 1990)	Optical Emission Spectrometry (ICP)

Data-adjustment: differentiation between mineral and organic soil carbon

As a second alternative method, organic carbon was calculated by using a C:N-ratio of 20:1. As nitrogen concentration in soils cultivated according to organic standards should derive to a great extent from organic sources, high nitrogen concentration always indicates high organic matter concentration.

In order to minimize methodical errors, organic carbon was calculated as mean value of carbon determined by both methods: $C_{org} = ½ (C_{West}+C_{C:N})$

Mineral carbon concentrations were calculated by the subtraction of the organic carbon from total carbon: $C_{min}=C_{total}- C_{org}$

The transformation to $CaCO_3$-concentration was done by multiplication C_{min} with the factor 8.3 (=$CaC0_3$ in g /C in g).

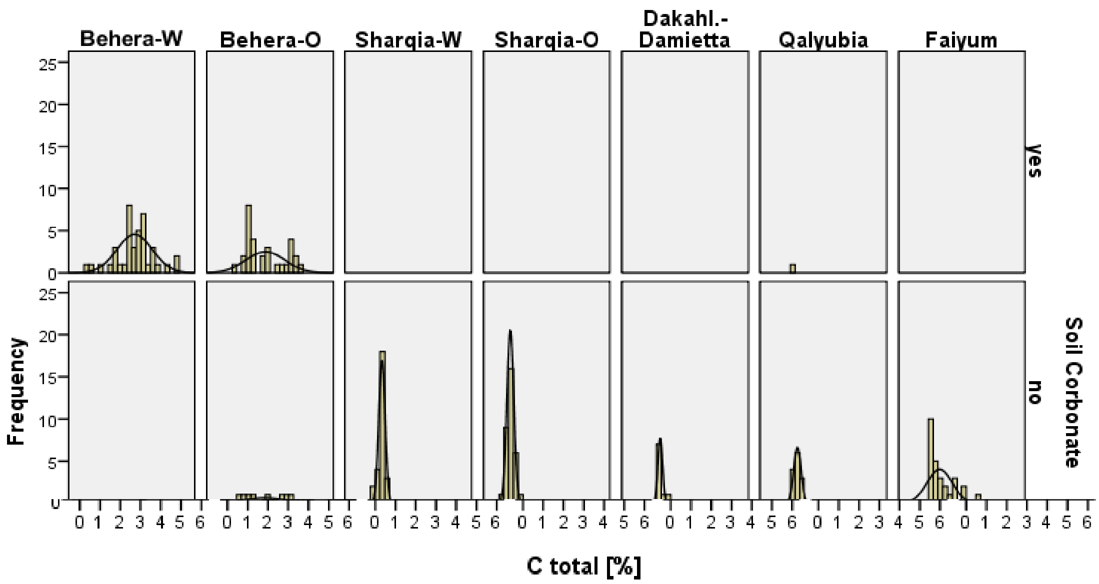


Fig. 3.6: Histograms of total carbon concentration versus visually diagnosed carbonates in Egytian soils, grouped according to sampling regions.

Fig. 3.7: Soil at the Beheira governorate (farm no. 685), Egypt, showing particles of sea shells.

Fig. 3.8: Soil at the Sharkia governorate (farm no. 764), Egypt, showing shrinking cracks and red mineral deposits on the soil surface.

Fig. 3.9: Soil at the Faiyum governorate (farm-no. 6772), Egypt, showing shrinking cracks and red mineral depositions.

3.3.2 Plant analysis of main chemical properties

Element concentration in leaf blades were analyzed according to the methods listed in Tab. 3.2.

Tab. 3.2: Plant analytical methods employed at the Institute for Crop and Soil Science, Julius Kühn-Institute, Braunschweig, Germany.

Parame-ter	Dimen-sion	Combustion/digestion	Analytical method (reference)
N, C	%	None	Elemental analyser, vario MAX CNS
P, K, Ca, Mg	g/kg	dry combustion or microwave digestion, dilution in nitric acid	inductively coupled plasma optical emission-spectrometry (ICP-OES), inductively coupled plasma mass spectrometry (ICP-MS)
B, Fe, Mn, Cu, Zn, Mo	mg/kg	dry combustion or microwave digestion, dilution in nitric acid	inductively coupled plasma optical emission-spectrometry (ICP-OES), inductively coupled plasma mass spectrometry (ICP-MS)
S	g/kg	none	X-RF (X-ray fluorescence) (Schnug and Haneklaus, 1992)

Pre-test: Evaluation of contaminations of leaf surfaces

Some of the plant tissue samples were visibly covered with dust (Fig. 3.10). In order to estimate the influence of dust and dirt on the results of plant tissue analyses, either through dust immission on the field or through contamination during the drying process, six samples picked in 2010 (governorate Faiyum) were split, one half remained untreated while the other half was carefully rinsed with water (Fig. 3.11).

Fig. 3.10: Organically grown Egyptian cotton (*Gossypium barbadense*) on a field of the Faiyum governorate, leaves visibly covered with dust.

Fig. 3.11: Part of leaf samples of organically grown Egyptian cotton after carefully rinsing the surfaces in order to remove superficial contamination.

Tab. 3.3 gives the result of this pre-test, revealing that the concentrations of C, P, S, K, Ca and Mg do not significantly differ and that the concentration of Fe differs with a high level of significance. Traces of the elements N, B, Mn, Cu and Zn in treated and untreated leaf samples did differ on a low significance level. These results imply that no contamination of leaves with C, P, S, K, Ca and Mg has to be considered, slight contamination of N, B, Mn, Cu and Zn should be taken into account and superficial contamination with Fe, possibly due to dust and dirt, are definitely to be considered when interpretating results of tissue analyses. The results are in accordance with finding of (Sillanpää, 1982), who discarded all Fe-analyses from original plants in a world-wide study on micronutrients due to obvious contamination.

Tab. 3.3: Effect of rinsing cotton leaf samples before drying on analysed element composition.

Parameter	Treatment	Mean	Std. Deviation
C_{total} [%]	a (no treatment)	41.9	1.6
	b (leaves rinsed)	42.5	1.7
N_{total} [%]	a	4.2	0.4
	b	4.2	0.6
P [g/kg]	a	2.7	0.4
	b	2.6	0.4
S [g/kg]	a	9.56	1.5
	b	9.57	1.5
K [g/kg]	a	27.2	7.0
	b	26.9	7.4
Ca [g/kg]	a	26.5	8.3
	b	25.8	9.1
Mg [g/kg]	a	5.56	1.3
	b	5.27	1.3
Fe [mg/kg]*)	**a**	**643**	**245**
	b	**208**	**44**
Mn [mg/kg]	a	90.5	37.1
	b	74.9	14.5
Zn [mg/kg]	a	42.3	29.2
	b	27.4	9.8
Cu [mg/kg]	a	13.7	3.6
	b	11.9	1.4
B [mg/kg]	a	69.4	13.3
	b	61.9	12.4
Mo [mg/kg]	a	2.03	0.74
	b	1.94	0.75

*) significantly different (F-Test; $p< 0.05$).

3.4 Statistical analyses

3.4.1 Data transformation and grouping

Relative yield was calculated separately for each year as quotient of absolute yield reported farmwise to mean yield in the corresponding year, as practiced by Schnug et al. (1995).

Farms were grouped according to their geographical position as indicated by their GPS code (Fig. 3.1, Tab. 8.7, Appendix) and an available soil map (Hammad, 1976). Farms of the Beheira governorate, which were scattered over a large area, were separated in a western and an eastern group (Beheira-W and Beheira-O), as local factors, like the influence of the near Mediterranean Sea had to be considered. Sampling locations at the Sharqia governorate were quite numerous and situated in different sampling areas, so that a separation in a western and an eastern group was executed here as well (Sharqia-W and Sharqia-O). Farms from the Damietta and Dakahlia governorates were merged to one group, as they were few in number and neighbouring. Due to the smaller number of farms in the governorates of Qalyubia and Faiyum, farms in these two groups were kept as one group each; no subdivision was executed despite the distances of the farms in the governorates from each other.

3.4.2 Methods for the description and comparison of groups of samples

Data were statistically analyzed by means of the Statistical Package for Social Science (SPSS), version 17.0 (SPSS, 2010).

Precondition for the deduction of representative critical values from a data set is that the distribution of each group of data (for yield, plant- and soil characteristics) is normal. This can be visualized by the SPSS- option “histogram" (inclusive normal distribution curve). The extent of normal distribution of a group of samples was tested using the one-sample Kolmogorow-Smirnow test. The null hypothesis of this test states that a distribution is normal. This assumption has to be rejected in case of a high Kolmogorow-Smirnow value and a low significance (Brosius, 2005). The degree of skewness and kurtosis are further attributes which explain how strong a distribution distinguishes from normal. A negative skewness implies extrema on the left side of the distribution curve, a positive skewness on the right side of the curve. A positive value for kurtosis implies that the distribution is steeper that a normal curve, a negative value implies a flatter shape of the curve (Brosius, 2005).

One-way analysis of variance (ANOVA) was employed to investigate whether there was a firm statistical difference between groups (seven sampling regions, three years of sampling and two certification standards) with reference to the yield performance. Additionally, two-way ANOVA was used to determine the influence of sampling regions, years of sampling and the interaction of year and region (SPSS, 2010).

Correlations between groups were calculated by means of Spearman’s rho bivariate correlation analysis provided by the SPSS-package, choosing a 2-tailed significance at 0.01 level (SPSS, 2010).

Stepwise linear regression was used to explore with which of the variables among the soil constituents plant nutrient concentrations could be explained (SPSS, 2010).

3.4.3 Methodical approach for elaborating critical values

One objective of this research work was to develop a method with which boundary lines can be computed from a given data set. Furthermore, the obtained values shall be compared to other methods for the deduction of critical values.

3.4.4 Heym and Schnug: Boundary Line Developement System (BOLIDES)

Mathematica 7 was used for programming algorithms to obtain a boundary line (Wolfram Research Inc., 2010). For this purpose, the 5-step-algorithm, proposed by Heym and Schnug (1995), was computed into Mathematica expressions.

Data preparation and calculation of basic statistical parameters

Lists of the following data were created: relative yield [%], C total [%], N total [%], P [g/kg], S [g/kg], K [g/kg], Ca [g/kg], Mg [g/kg], Fe [mg/kg], Mn [mg/kg], Zn [mg/kg], Cu [mg/kg], B [mg/kg], Mo [mg/kg], Na [mg/kg].

All lists followed the same sequence of data, i. e. data on the first position of each list referred to the same farm “a” and all data on position c were obtained from another farm “c”. Further programming in Mathematica 7 is exemplarily explained for the nutrient phosphorus.

x-coordinates: pfP={3.79,3.22, …..., 4.42};

y-coordinates: relYield={115, 94, …...,87};

Data were ordered in pairs, one pair each referring to the same farm:

relYieldE=Transpose[{pfP, relYield}];

The original data set is shown in the Fig. 3.12:

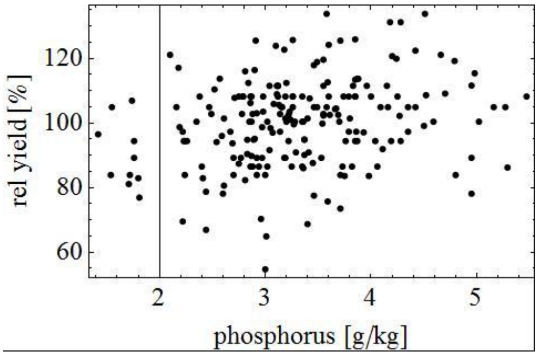


Fig. 3.12: Scatter plot of P concentration of young, fully matured main stem leaves / relative yield of organically grown Egytian cotton.

Now, data were sorted with respect to the first coordinate in an ascending order:

```
relYieldE1=Sort[relYieldE,(#1[[1]]<#2[[1]]&)]
```

Minimum and maximum values for x and y were calculated:

```
{xmin,xmax}={Min[Transpose[relYieldE1][[1]]],
Max[Transpose[relYieldE1][[1]]]}
```

```
{1.42, 5.47}
```

```
ymin,ymax}={Min[Transpose[relYieldE1][[2]]],
Max[Transpose  [relYieldE1][[2]]]}
```

```
{54.7, 133.8}
```

With the following expression, a scaling of the data set limited to the range (0,1)×(0,1) for the x and y values was executed:

```
fromUserData=RescalingTransform[{{xmin,xmax},{ymin,ymax}}]
```

$$\text{TransformationFunction}\left[\left(\begin{array}{cc|c} 0.246914 & 0. & -0.350617 \\ 0. & 0.0126422 & -0.69153 \\ \hline 0. & 0. & 1. \end{array}\right)\right]$$

A transformation of the scaled data to the orginal data set was executed by the following expression:

```
scaledToUser=RescalingTransform[{{0,1},{0,1}},{{xmin,xmax},{ymin,ymax}}]
```

$$\text{TransformationFunction}\left[\left(\begin{array}{cc|c} 4.05 & 0. & 1.42 \\ 0. & 79.1 & 54.7 \\ \hline 0. & 0. & 1. \end{array}\right)\right]$$

Step 1, outlier reduction

A scaled data set, limited to the range (0,1)×(0,1) for the x and y values, was derived from the original data:

```
normalPoints=Map[fromUserData[#]&,relYieldE1];
```

The Frobenius norm (also known as Euclidean norm) is a matrix norm of a *m*×*n* matrix *A*, defined as the square root of the sum of the absolute squares of its elements (Weisstein, 2011). Based on the Frobenius norm, the nearest neighbours were calculated:

```
nf=Nearest[MapThread[#1->#2&,{normalPoints,Table
[i,{i,Length[normalPoints]}]}], DistanceFunction->(Norm[#1-
#2,"Frobenius"]&)];
```

The nearest neighbour areas in the scatter diagram P tissue concentration / relative yield are shown in Fig. 3.13:

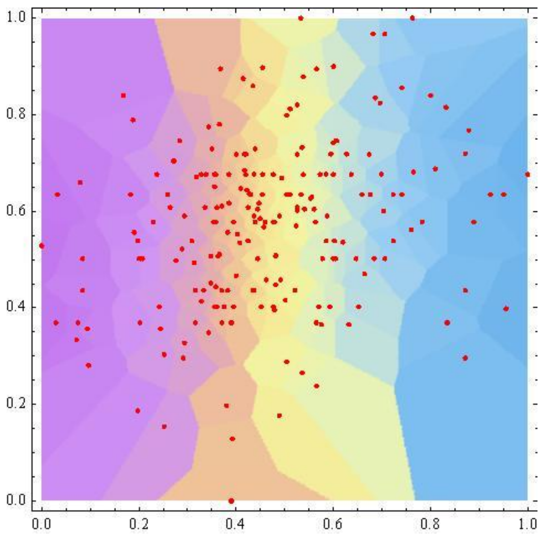


Fig. 3.13: Nearest neighbour areas on the basis of the Frobenius norm for a scatter diagram showing P tissue concentration / relative yield of organically grown Egyptian cotton.

On the basis of the partition of points into nearest neighbourhood areas, the neighbourhood with respect to the mean values of x and y was determined. Supposing that only a few data points are identified as outliers, mean values of the coordinates x and y are located inside the main bulk of the data set:

```
{meanX,meanY}={Mean[Transpose[normalPoints][[1]]],
Mean[Transpose[normalPoints][[2]]]}
```

```
{0.465,0.573}
```

Data points in the scaled coordinates were selected as basis of regular data points; the number of selected data points was set at 190 in the case of phosphorus:

```
selectedPoints=Nearest[normalPoints,{meanX,meanY},190,DistanceFunction-
>(Norm[#1-#2,"Frobenius"]&)];
```

The determined points in the scaled coordinates were then transformed back to original coordinates by the following scaling transformation:

```
reducedData=Map[scaledToUser[#]&,selectedPoints]
```

Fig. 3.14 shows the selected nearest points (in this example 190) in black and the outliers colored in magenta:

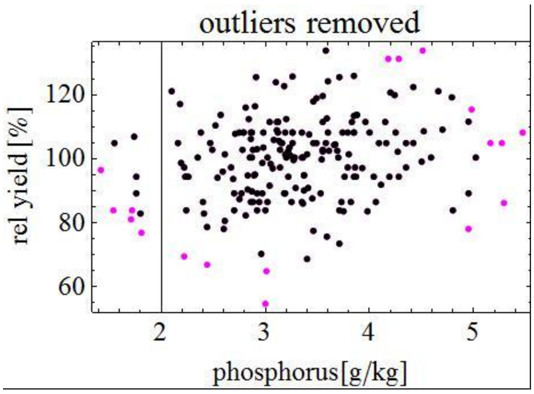


Fig. 3.14: Scatter plot of P concentration in young, fully matured main stem leaves / relative yield of organically grown Egyptian cotton; outliers (magenta points) identified by use of the Frobenius norm.

Step 2, classification

Classification of data proposed as second step by Heym and Schnug (1995) can be omitted in the present example, as tissue concentration of phosphorus in leaves is approximately normally distributed (Tab. 8.5 and Fig. 8.2, Appendix).

Step 3, upper boundary step function

As an approximation for the upper boundary line, an upper boundary step function was constructed; first, the reduced data set was sorted with respect to the first element and the x coordinates were sorted in an ascending order:

```
relYieldE2=Sort[reducedData,(#1[[1]]<#2[[1]]&)];
xCoordinates=First[Transpose[relYieldE2]];
```

Next, the data set was divided into groups with a fixed number of elements (in this example 25 data points) in ascending order with respect to the x-coordinates. With respect to the corresponding y-coordinates, all elements of one group were lifted to the level of the largest element of this group:

```
yCor=Table[Max[Last[Transpose[Select[relYieldE2,(xCoordinates[[i]]≤#[[1]]&&
#[[1]]≤ xCoordinates[[i+25]])&]]]],{i,1,Length[relYieldE2]-25}];
```

For the same grouping, a mean value for the y-coordinates of each group was calculated:

```
xCor=Table[Mean[First[Transpose[Select[relYieldE2,(xCoordinates[[i]]≤#
[[1]]&&#[[1]]≤xCoordinates[[i+25]])&]]]],{i,1,Length[relYieldE2]-25}];
```

Finally, the coordinates were assembled in order to build up the upper "step function":

```
upperBorder=Transpose[{xCor,yCor}];
```

This algorithm gave an approximation of the upper boundary line for the scatter plot P concentration / relative yield, but not of the left respectively right side of the scatter plot. Therefore left and right boundary steps were introduced, in order to better fit a polynomial curve to the right and left side of the plot.

Left and right side points were constructed by "turning the scatter plot at 90° to the right side" and then applying a similar procedure as exercised for the upper boundary line (Fig. 3.15). For this purpose, first, the reduced data set was sorted with respect to the second element, the y-coordinates were sorted in an ascending order and x- and y-coordinates were transposed to x1- and y1-coordinates.

```
relYieldE3=Sort[reducedData,(#1[[2]]<#2[[2]]&)];
x1Coordinates=Last[Transpose[relYieldE3]];
y1Coordinates=First[Transpose[relYieldE3]];
transf=Transpose[{x1Coordinates,y1Coordinates}];
```

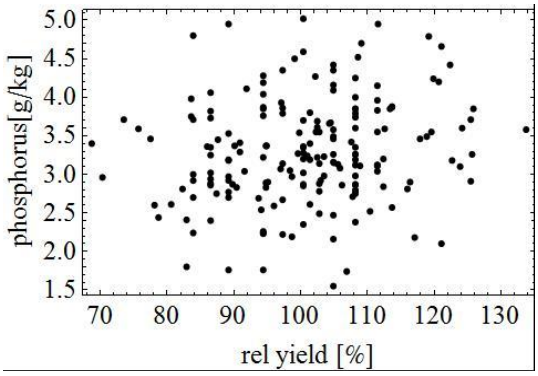


Fig. 3.15: Scatter plot of P concentration of young, fully matured main stem leaves / relative yield of organically grown Egyptian cotton; outliers removed, original graph turned by 90°.

The same procedure as for the upper boundary step function executed was applied, the data set was divided into groups with a fixed number of elements (in this example 35 data points) in ascending order with respect to the x1-coordinates.

In order to establish the left hand side boundary line, all y1-coordinates were lowered to the level of the smallest element of this group:

```
x1Cor=Table[Min[Last[Transpose[Select[transf,(x1Coordinates[[i]]
≤#[[1]]&&#[[1]]≤x1Coordinates[[i+35]])&]]]],{i,1,Length[relYieldE3]-35}];
```

In order to establish the right hand side boundary line, all y2-coordinates were lifted to the level of the largest element of this group.

```
x2Cor=Table[Max[Last[Transpose[Select[transf,(x1Coordinates[[i]]≤#[[1]]&&#[
[1]]≤x1Coordinates[[i+35]])&]]]],{i,1,Length[relYieldE3]-35}];
```

For the same groupings, a mean value for the x1-coordinates of each group was calculated:

```
y1Cor=Table[ Mean[First[Transpose[Select[transf,(x1Coordinates[[i]]
≤#[[1]]&&#[[1]]≤x1Coordinates[[i+35]])&]]]],{i,1,Length[relYieldE2]-35}];
```

Again, the coordinates were assembled in order to build up the left side and the right side “step functions”:

```
leftBorder=Transpose[{x1Cor,y1Cor}];
rightBorder=Transpose[{x2Cor,y1Cor}];
```

Left, upper and right boundary lines are depicted in the following graph (Fig. 3.16):

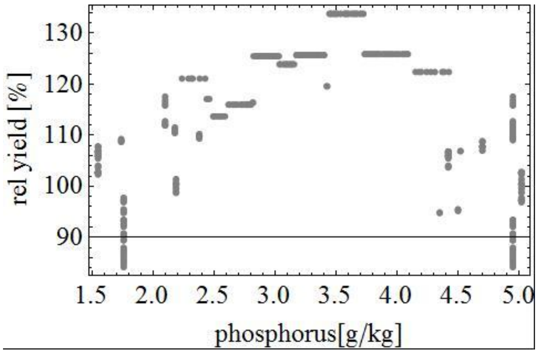


Fig. 3.16: Left, upper and right boundary lines for the relation of P concentration in young, fully matured main stem leaves/ relative yield of organically grown Egyptian cotton, developed applying the boundary step function according to Heym and Schnug (1995).

Step 4, upper boundary line-function

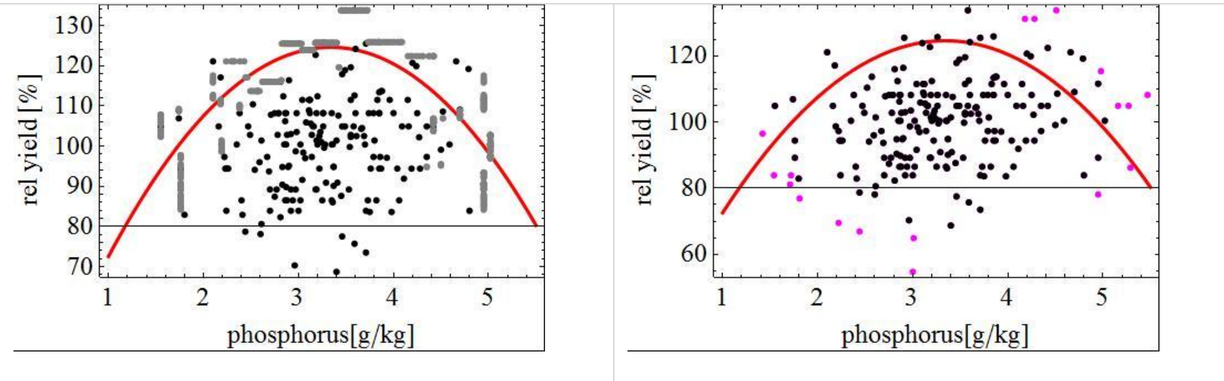
The “fit- procedure” of Mathematica was used to establish the upper boundary line-function. In most cases (in which the values were more or less normally distributed), polynomials up to order 4 could be adjusted to the step functions established and the best fitting function was selected.

Some elements (micronutrients) showed an extreme positive skewness (with many outliers on the right side of the distribution curve) and a positive value for kurtosis, i. e. the distribution was steeper than a normal curve. In these cases, a Mitscherlich curve seemed adequate to describe the relation between plant nutrient concentration and yield.

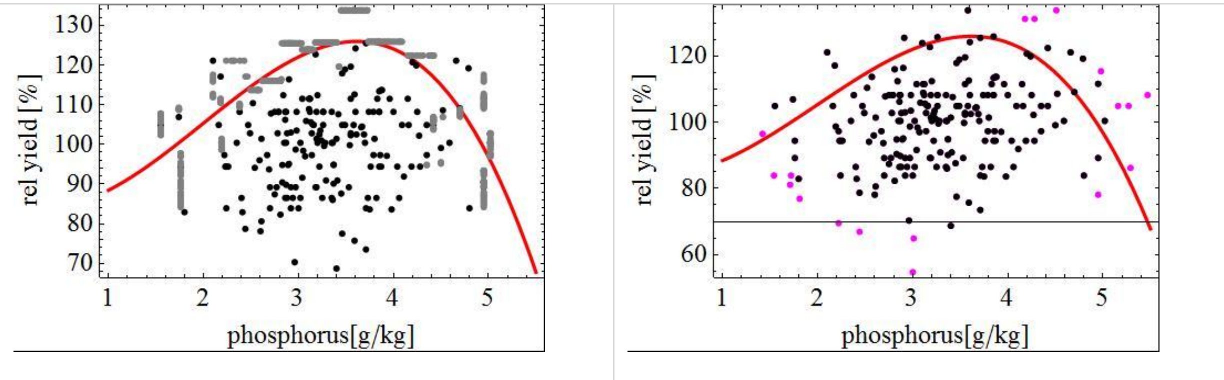
Fitting procedure for polynomials up to 4th degree

```
poly=Fold[Plus,0,Table[h[i]z^(i-1),{i,1,3}]]

h[1]+z h[2]+z^2 h[3]

fitRes=FindFit[boundaryPoints,poly,{h[1],h[2],h[3]},z]

{h[1]→18.5642,h[2] →63.48,h[3] →-9.50115}

polyFit=poly/.fitRes

18.5642+63.48z-9.50115z^2
```

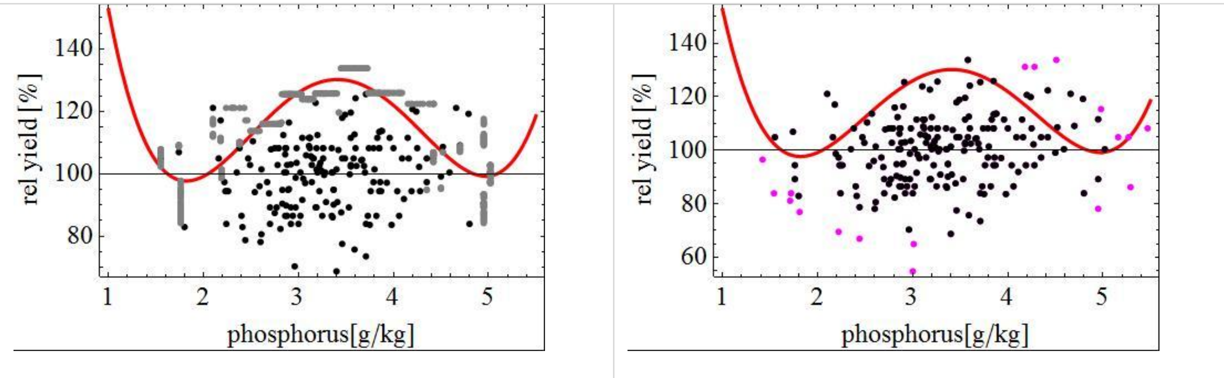
Fig. 3.17 shows the graphs and functions of the resulting polynomials of 2nd, 3rd and 4th order in association to the reduced data set and the boundary steps as well as in association with the original data set (outliers and reduced data set):



$$y=18.5642+63.48x-9.50115x^2$$



$$y=85.8188-9.35281x+14.3922x^2-2.41605x^3$$



$$y=520.736-634.66x+331.283x^2-69.9596x^3+5.14348x^4$$

Fig. 3.17: Polynomial of 2nd, 3rd and 4th order fitted to the step function (gray points) and drawn in relation to original scatter diagram with outliers marked (magenta points); data refer to P concentration of relative yield / young, fully matured main stem leaves of organically grown Egyptian cotton.

Step 5, optimum values and optimum ranges

The optimum nutrient value level is determined by the zeros of the first derivative of the upper boundary line and the sign of the second derivative at this point (Heym and Schnug, 1995):

```
func=f[z]=poly/.fitRes
```

$18.6+63.5\ z-9.5\ z^2$

```
f'[z]
```

```
63.5 -19.0 z
```

```
f''[z]
```

```
19.0
```

The x-value of the critical value is calculated by equalling the 1st derivate of the boundary line equation to zero:

```
sol=Solve[f'[z]==0
```

```
{{z→3.34}}
```

```
sol1=sol[[1]]
```

```
{z→3.34}
```

The y-value of the critical value is obtained by solving the equation of the boundary line function for the x-value:

```
cvy=func/.sol1
```

```
124.6
```

The critical value for phosphorus is thus calculated as (3.34, 124.6), i. e. the concentration of 3.34 g/kg dm phosphorus in young, fully matured cotton leaves corresponds to a maximum relative yield of 125 %.

The sufficiency level is calculated by limiting the y-value to 95 % of the maximum yield and solving the boundary line equation for this y-value. As result, the left and right limiting point of the critical nutrients range with the coordinates (2.53, 118.4) and (4.15, 118.4), is obtained. In other words: 95 % of the maximum yield can be obtained with P-concentrations between 2.53 and 4.15 g/kg dm.

```
cvrange=cvy*0.95
118.4
Solve[cvrange==func,z]
{{z→2.53}, {z→4.15}}
```

Validity range

The lower end of the validity range is defined as lowest nutrient level not excluded as outlier, the upper end of the validity range is defined as upper end of the sufficiency range.

Beaufils and Sumner (DRIS): Mean values of the high yielding subpopulation

Critical values for calculations according to DRIS are obtained by defining a high yielding population and taking its mean values as critical values (see chapter 0, Beaufils and Sumner, 1976). For this purpose, relative yields and leaf nutrient concentrations of all sites and years were listed in an Excel-sheet in decending order. Mean values and standard deviations of the population of the best 15 % were computed and taken as target values for further calculations.

Cate and Nelson: Iteration process using a coefficient of determination

In order to execute the Cate and Nelson (1971) procedure (see chapter 2.2.2), the operations as explained by the authors were transferred to an Excel sheet and then applied to the data set.

Khiari et al. (CND): Iteration process using the cumulative variance ratio

For each nutritious element, cumulative variance ratios were computed on an Excel sheet as proposed by Khiari et al. (2001a). The ratios were plotted and thus the matching cumulative variance ratio equations were obtained. Inflection points as cut-off-levels for low and high yielding subpopulations for several nutrients were calculated as proposed by the authors.

3.4.5 Methodical approach for the evaluation of plant data

Another objective of the present research work was the evaluation of the nutrient status of organically grown Egyptian cotton (*Gossypium barbadense*). For this purpose, the boundary line functions determined for different plant nutrients were connected to PIPPA-algorithms (see chapter 2.3.1, Heym and Schnug, 1995). The evaluation system was programmed in Excel. The complete data set of plant nutrient concentrations for all farms and all years was used to evaluate the nutritional status of Egyptian organic cotton. The following elements were included: N, P, S, K, Ca, Mg, Fe, Mn, Zn, Cu, B and Mo.

In addition to the actual evaluation according to PIPPA, which aims at the diagnosis of nutrient deficiencies, excess plant tissue element concentrations were calculated with respect to the critical values determined by BOLIDES. The individual nutrient concentration in plant tissue was for this purpose compared with the critical value, which was set relative as 100 %. It shall be pointed out, that for this part of the evaluation, there is no relation to yield performance, as there is for PIPPA itself. This approach does, nevertheless, allow the comparison of an univariate approach of plant evaluation with the bi- and trivariate approaches of DRIS and CND with respect to the nutrients in surplus concentration in plant tissue.

A comparison of evaluation systems is the aim of this research work too: for this purpose, the simplified DRIS-approach (see chapter 2.3.2, Beaufils, 1973; Beaufils and Sumner, 1976) as proposed by Walworth and Sumner (1987), was programmed in Excel.

As a second alternative, CND as published by Parent and Dafir (1992) (see chapter 2.3.3), was chosen and algorithms were programmed in Excel, too. Again, the complete data set was used and the nutritional status of Egyptian organically grown cotton according to DRIS and CND was determined for each farm and each year.

3.4.6 Methodical approaches for the comparison of the results of individual evaluations carried out with PIPPA, DRIS and CND

Two ways were chosen to compare the three systems for the evaluation of plant analysis data:

Individual approach: Deficiency indices calculated according to PIPPA, DRIS and CND were compared with respect to eight individual cotton leaf tissue samples from different sampling sites.

Statistical approach: Mean values with respect to the different seven sampling regions as well as the three years of sampling were calculated concerning the following data:

- deficiency indices determined according to PIPPA ,
- excess supply indices determined by comparing the individual analysis data with critical values according to BOLIDES,
- indices determined according to DRIS and CND separately for deficiencies and excess values.

4 Results

4.1 Yield of organically grown Egyptian cotton

The yield of cotton was chosen as the target value for this investigation, as farmers are paid for the absolute yield of raw cotton (seeds and fibers) irrespective of the fiber quality, which decreases from the first to the third picking.

The mean yield of organically grown cotton as recorded in the present study amounted to 3,473 (±481) kg/ha for the years 2008-2010 (seeds and lint). This is well above the mean world cotton yield of 2,140 kg/ha with respect to the reference year 2007. Only China in that year attained a mean yield well above the Egyptian figures with 4,210 kg/ha, while mean values for the United States only attained 2,830 kg/ha and for India only 1,020 kg/ha (UNCTAD, 2011). Organically grown cotton in Egypt thus attains about the same yield level as reported with 3,762 to 4,250 kg/ha for conventionally grown *Gossypium barbadense* in field trials carried out by the national Egyptian cotton research institute (Sawan et al., 2008).

Fig. 4.1 shows the distribution of yields as histogram in comparison to a normal distribution curve. A deviation from a normal distribution is indicated by the Kolmogorow-Smirnow test, too. A number of outliers on the left hand side (i.e. low yields) are indicated by a negative value for skewness. The curve is flatter than for a normal distribution (Tab 8.15, Appendix).

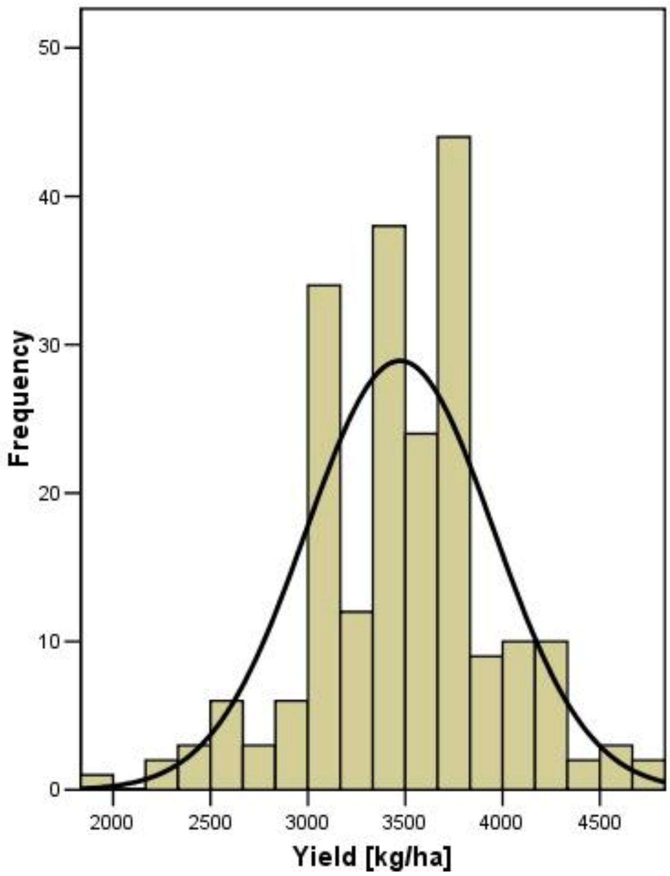


Fig. 4.1: Histogram of total cotton yield (kg/ha) of organically grown Egyptian cotton (*Gossypium barbadense*) in 2008-2010.

Separate histograms for each year show the difference in level and distribution of total yields (Fig. 4.2). Mean yields amounted to 3,625 kg/ha in 2008, to 3,363 kg/ha in 2009 and to 3,416 kg/ha in 2010. Yields were significantly elevated in 2008 in comparison to the other two years (Tab. 8.19, Appendix). Especially for 2010, recorded yields were not distributed normally. In order to compensate the inequalities related to the absolute amount of yield, for the determination of critical values, absolute yields were transferred to relative yields with respect to each year (chapter 3.2). A lower Kolmogorow-Smirnow value of the distribution of relative yields in comparison to absolute yields indicates a better resemblance with a normal distribution curve (see Tab. 8.16, Appendix).

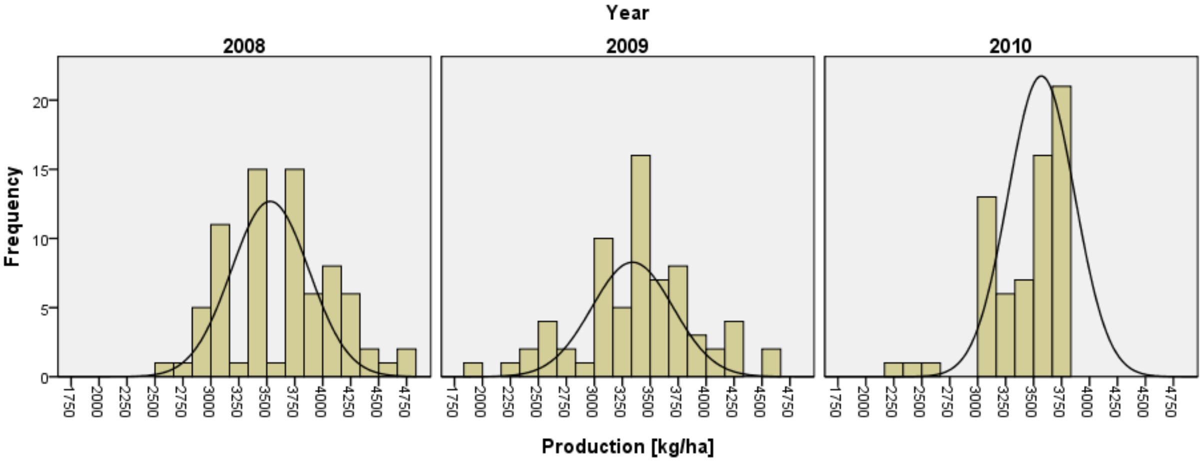


Fig. 4.2: Histogram of total cotton yield (kg/ha) of organically grown Egyptian cotton (*Gossypium barbadense*) separately for the years 2008, 2009 and 2010.

According to one-way ANOVA, total cotton yields are significantly different with respect to the sampling sites (Fig. 4.3, Tab. 8.17, Appendix). Mean yields of Beheira-W and Beheira-O did not significantly differ from each other. Mean yields in Sharqia-W and Sharqia-O also belong to one homogeneous subset (One-way ANOVA, Tuckey HSD-Test, $p<0.05$). Mean absolute yield over the whole sampling period was in Beheira-W 3,724 kg/ha, in Beheira-O 3,714 kg/ha, in Sharqia-W 3,119 kg/ha, in Sharqia-O 3,414 kg/ha, in Dakahlia-Damietta 3,124 kg/ha, in Qalyubia 3,427 and in Faiyum 3,165 kg/ha.

Total production of lint and seeds per ha and year amounted with respect to the cultivar GIZA 85 to 3,123 kg/ha, for GIZA 86 to 3,540 kg/ha and for GIZA 90 to 3,164 kg/ha. Mean production figures of GIZA 86 were significantly higher than of GIZA 85 and GIZA 90 (one-way ANOVA, Tuckey HSD-Test, $p<0.05$). As government stipulated certain cotton cultivars for certain sampling region, characteristics of the regions would always influence the interpretation of yield performances of different cultivars (see also Tab. 8.8 to Tab. 8.11). No further evaluations were executed concerning the different cultivars GIZA 85, GIZA 86 and GIZA 90, due to the considerable difference in group size and undeterminable regional effect on cultivar performance.

For the comparison of total cotton production with respect to the certified cultivation standard, only farms at the Beheira governorate were chosen, as in this governorate, there were a large number of farms certified as “demeter” and “organic” and it could be expected that overall-conditions (soil, climate, irrigation, fertilization, cotton cultivar used) are comparable. While farms certified as “demeter” dominated in the western part of the governorate (Beheira-W), farms certified as “organic” were situated in the eastern part of the governorate (Beheira-O). Mean yield for according to “demeter” rules cultivated cotton was 3,736 kg/ha (±419), for “organic” cotton yields amounted to 3,707 kg/ha (±487). According to ANOVA-analysis, there was no significant difference in total mean yield between cotton being certified as “organic” and “demeter” ($p<0.05$).

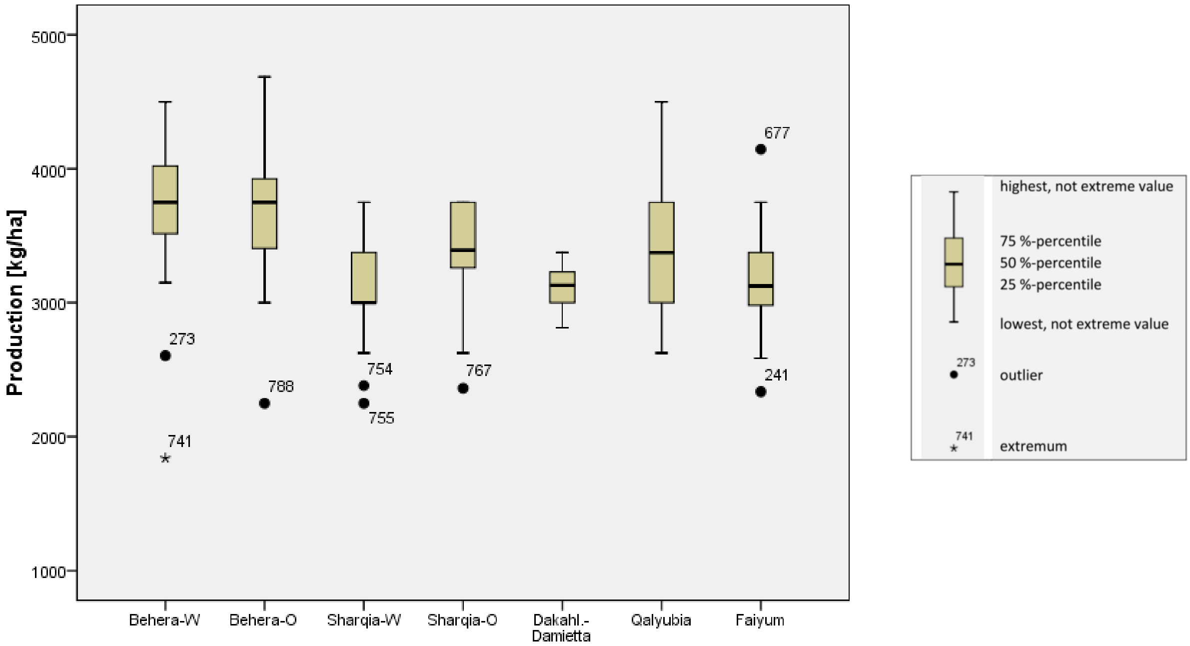


Fig. 4.3: Boxplot of total cotton yield (kg/ha) in seven different regions of organically grown Egyptian cotton (*Gossypium barbadense*) in 2008-2010.

4.2 Nutrient supply of Egyptian cotton fields

4.2.1 Data over all years and sites

Tab. 4.1 gives an overview over the chemical characteristics of the analyzed Egyptian soils. Information on their statistical distribution (test on skewness and kurtosis, Kolmogorow-Smirnow-test) is listed in the Appendix (Tab. 8.15). Histograms compiled in Fig. 8.1 in the Appendix visualize the distribution of the data in comparison to a normal distribution curve. According to the above listed information, the following distribution patterns can be distinguished:

- Approximately normal distribution: Zn_{West},
- Distributions with a certain negative skewness, due to some outliers representing low concentrations: Cu_{West}, Cu_{LE}, Al_{LE},
- Distributions with a certain positive skewness, caused by a number of outliers with high concentrations: pH, C_{org}, N_{total}, S, K_{CAL}, K_{LE}, $Mg_{Schacht}$, Zn_{LE},
- Distributions which show two maxima, one at a lower concentration, representing more samples and one at a higher concentration, representing less samples: C_{total}, $CaCO_3$, P_{H2O}, P_{Olsen}, P_{CAL}, P_{LE},CA_{LE}, Fe_{LE},
- Distributions which show more than two maxima: Mg_{LE}, Mn_{LE}, B_{LE}, Mo_{LE}, electrical conductivity, Na,

- C_{total}, CA_{LE}, Mg_{LE}, Mn_{LE} Cu_{West} and Na show a flatter distributed than normal, all other parameters follow a steeper than normal distribution.

Tab. 4.1: Statistics of soil parameters of fields of organically grown Egyptian cotton in 2008-2010 in comparison with data of an international status report (Sillanpää, 1982).

Parameter	n	Mean	Minimum	Maximum	Std. Deviation	(Sillanpää, 1982)[1)] Wheat soils (n=100)	(Sillanpää, 1982)[1)] Maize soils (n=100)
pH-value	208	7.91	7.40	8.89	0.20	7.74±0.14	
C_{total} [%]	206	2.16	0.71	5.35	1.05		
C_{org} [%]	135	1.17	0.21	4.31	0.58	1.19±0.3	
$CaCO_3$ [%]	134	8.60	-11.90	30.2	7.33		
N_{total} [%]	207	0.09	0.00	0.41	0.06	0.13±0.3	0.12±0.3
P_{H2O} [mg/kg]	134	11.6	1.20	77.6	17.7		
P_{CAL} [mg/kg][2)]	207	168	35.6	664	115		
P_{LE} [mg/kg]	125	146	3.76	530	139		
P_{Olsen} [mg/kg]	207	39.1	4.99	294	42.4	13.9±10.2	11.7±9.9
S_{LE} [mg/kg]	208	992	42	10,241	1,387		
K_{CAL} [mg/kg][3)]	208	604	144	4,307	737		
K_{LE} [mg/kg]	208	964	300	5,912	1,005	535±228	470±226
Ca_{LE} [mg/kg]	208	28,536	8,492	61,967	16,187	5,563±977	4,702±730
$Mg_{Schacht}$ [mg/kg]	208	739	223	1,998	296		
Mg_{LE} [mg/kg]	208	2,635	1,085	4,336	766	1,170±338	895±276
Fe_{LE} [mg/kg]	170	182	0.62	440	74	1,426±690	
Mn_{LE} [mg/kg]	208	226	32.1	456	107	89±34	
Zn_{West} [mg/kg]	81	8.03	0.00	21.8	5.39		
Zn_{LE} [mg/kg]	189	4.02	0.34	80.6	6.78	8.7±7.7	
Cu_{West} [mg/kg]	81	9.40	0.33	26.1	6.44		
Cu_{LE} [mg/kg]	184	11.3	0.19	27.4	5.23	85.5±27.3	
B_{LE} [mg/kg]	81	5.36	1.64	14.9	3.87	(6.9±2.8)	
Mo_{LE} [mg/kg]	120	0.03	0.00	0.33	0.05	(0.19±0.06)	
Na [mg/kg]	81	1,344	175	3,703	1,008	(1,007±926)	
el. conductivity [µS/cm, 25°C]	81	1,337	140	4,500	1,268	(7,800±5,500)	
Al_{LE}[mg/kg]	180	144	2.47	231	54.2		

[1)] Figures converted from mg/l to mg/kg by factor 1.35 (specific weight of the soil); data in brackets indicate a limited comparability due to differences in applied method of analysis;

[2)] target value according to VDLUFA for P_{CAL}: 45 to 90 mg/kg soil (concentration level "C"), (Kerschberger et al., 1997);

[3)]target value according to VDLUFA for K_{CAL}: 80 to 170 mg/kg for soils with 13 to 25 % clay and 110 to 220 mg/kg for soils with >25 % clay (concentration level "C"), (Baumgärtel et al., 1997).

Tab. 4.1 includes reference data of an international nutrient status report on soils (Sillanpää, 1982). Concerning Egypt, this study included 100 samples each from soils conventionally cultivated with wheat and maize, all of them situated in the "Old Land" (delta and Nile valley). Recent data show comparable values for the parameters C_{org} and N_{total}. Values of P_{Olsen}, K_{LE}, Ca_{LE} and Mg_{LE} are higher in the present study than at the end of the 70s of the last century. Despite the organic management of the farms, there is no increase in soil organic matter content visible. A decrease of soil N_{total} can be explained by the abdication of mineral fertilizers in organic farming. High P_{Olsen}- values in the present study may be due to the often practiced addition of poultry manure to the compost (Bordeny, 2010). Salinization may be an explanation for the increase of means of the pH-level, K and Ca, even though measured values for Na and electrical conductivity did not show a corresponding increase in comparison to 1980. Mean concentration of Mn_{LE} was higher and of FE_{LE}, Zn_{LE} and Cu_{LE} lower than in the study of Sillanpää (1982). Due to different methods applied, values for B, Mo and Na are not thoroughly comparable. At the end of the 70s, in the international comparison, Egypt's soil supply with N was average and with P was slightly below average. Concerning K, Ca and Mg, Egypt's soils ranked on top position, which was, according to the author, linked to fine textured soils with high exchange capacity and to medium to high pH-levels. In the international comparison, the concentrations of Fe, Cu, B and Mo in Egyptian soils were above average, on Zn on average level and of Mn below the average (Sillanpää, 1982). In comparison to German "VDLUFA" target values for P_{CAL} (Kerschberger et al., 1997) and K_{CAL} (Baumgärtel et al., 1997), the examined soils seem well equipped with phosphorus and potassium, as mean values of the examined soil well exceed these target values.

4.2.2 Variation for different years and sampling regions

With Tab. 4.2 it can be shown, that the year of sampling significantly influences the concentrations of some of the elements analyzed in the soils, except for the parameters C_{total}, P_{H2O}, Ca_{LE}, $Mg_{Schacht}$ and Al_{LE}. In general, there was a significant effect of the sampling regions on the variability of soil parameters; only the pH-level, Zn_{West}, Zn_{LE} and Mo_{LE} do not show a significant regional variation.

Tab. 4.2: Effect of site and year on the soil element composition of fields of organically grown Egyptian cotton, determined by two-way ANOVA (sampled in 2008-2010).

Parameter	Year	Region	Year*region
pH	-	-	-
C_{total}	-	+	+
C_{org}	+	+	-
$CaCO_3$	+	+	+
N_{total}	+	+	+
P_{H2O}	-	+	+
P_{CAL}	+	+	+
P_{LE}	+	+	+
P_{Olsen}	+	+	+
S_{LE}	-	+	-
K_{CAL}	+	+	+
K_{LE}	+	+	+
Ca_{LE}	-	+	+
$Mg_{Schacht}$	-	+	+
Mg_{LE}	-	+	+
Fe_{LE}	+	+	+
Mn_{LE}	+	+	+
Zn_{LE}	-	-	-
Zn_{West}	-	-	-
Cu_{LE}	-	+	+
Cu_{West}	+	+	-
B_{LE}	+	+	n.b.
Mo_{LE}	+	-	+
Al_{LE}	-	+	+
Na	+	+	n.b.
el. conductivity	+	+	n.b.

("+"=influence existing; "-"=influence not existing; $p<0.05$)

According to the results of a one-way ANOVA (Tab. 8.17, Appendix) with subsequent Tukey HSD-test, soil characteristics showed the below listed number of subsets. These subsets were also visible in the histograms of Fig. 8.1 (Appendix) as one, two or three distinct maxima or a pronounced positive skewness due to a larger number of outliers:

- no subset: pH, S_{LE}, Zn_{LE}, electrical conductivity,
- 2 subsets: C_{org}, P_{H20}, P_{LE}, P_{CAL}, P_{Olsen}, K_{CAL}, K_{LE}, Fe_{LE}, Zn_{West}, Cu_{LE}, B_{LE}, Na,
- 3 subsets: C_{total}, N_{total}, Mg_{LE}, Mn_{LE}, Cu_{West},
- 4 subsets: Ca_{LE}, $Mg_{Schacht}$, Al_{LE}.

A regional differentiation between locations in the Nile delta and Faiyum is also indicated by Fig. 4.4. The pie charts show the results of the texture analysis according to Durner (2008), a field method which allows a rough grouping of soils. The diagrams, in which the reddish colours signify fine textured soils and the yellowish colours coarse structured soils, visualize the difference in soil texture between soils of the central delta region, the coastal region and Faiyum. In the northern governorate Beheira, which is situated near to the Mediterranean Sea and at Faiyum “oasis”, the soils consist of a higher proportion of sand, while in the Sharqia governorate at the eastern part of the delta, the proportion of fine textured soils containing clay is quite high. Soils of Qalyubia, Dakahlia and Damietta seem to be, concerning the soil structure, in between both extremas, as these soils contain a high proportion of silt. However, only a few samples from these governorates participated in the investigation, therefore findings are of limited representativeness.

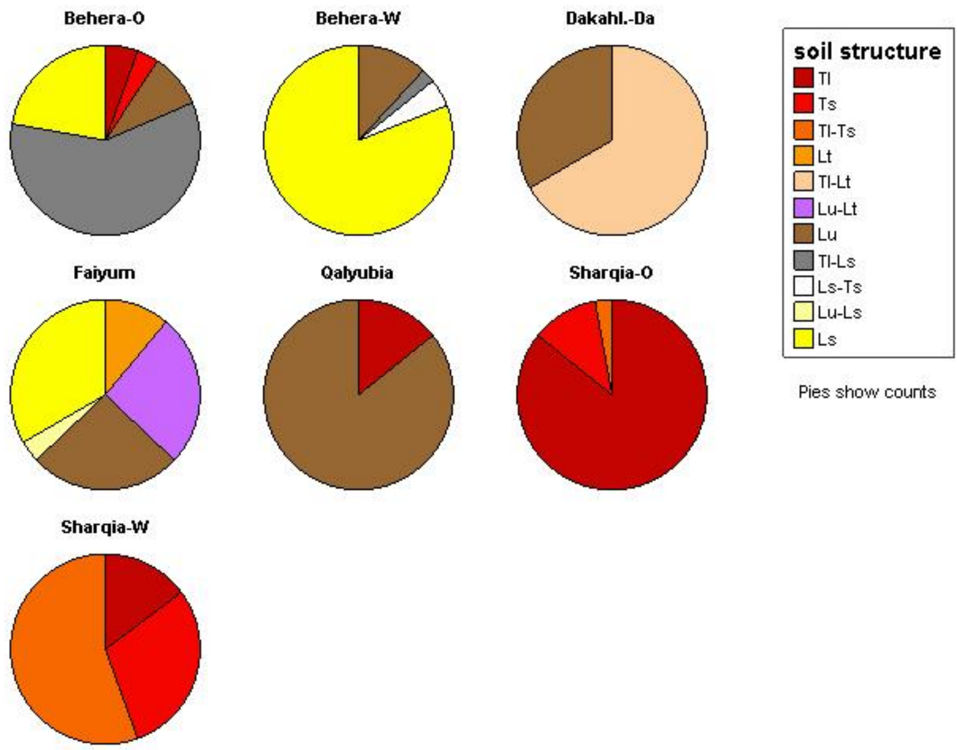


Fig. 4.4: Results of texture analysis for cotton grown soils in different governorates in Egypt sampled in 2008-2010, method according to Durner (2008).

4.2.3 Variation according to certified cultivation standards

Prerequisite for a reliable comparison of the cultivation standards “biodynamic” versus “organic” is, that the conditions for agricultural production are equal or at least comparable. Therefore a one-way ANOVA was executed for farms from the Beheira governorate only, concerning the characteristics of cotton soils grown “biodynamic” and “organic”. According to this test, the following parameters were statistically equal for both subgroups (p >0.05): pH-value, C_{org}, N_{total}, P_{CAL}, S_{LE}, $Mg_{Schacht}$, Mg_{LE}, Fe_{LE}, Mn_{LE}, Zn_{LE}, B_{LE}, Mo_{LE}, Na, electrical conductivity and Al (Tab. 8.18, Appendix).

A second group of parameters showed an elevated F-value and significance-value only slightly above the threshold-value of 0.05, which indicates, that there were some similarities between the two examined groups: P_{LE}, K_{CAL}.

A third group of parameters exhibited a significant difference in soil characteristics between biodynamically and organically grown cotton soils (p <0.05): C_{total}, $CaCO_3$, P_{H2O}, P_{Olsen}, Ca_{LE}, K_{LE}, Zn_{West}, Cu_{West} and Cu_{LE}.

4.3 Nutrient concentrations in cotton leaves

A pre-test revealed that dust emissions most probably have influenced mineral composition of the analyzed plant material (see chapter 3.3.2). Anyhow, no data-adjustment was executed, as the pre-test only covered a limited, not representative number of samples and in consequence there was no basis for a calibration of this adjustment.

4.3.1 Data over all years and sites

Tab. 4.3 gives an overview of mean nutrient concentrations over all sampling sites and over all three years of sampling.

Tab. 4.3: Mineral composition of tissue of young, fully matured main stem leaf blades of organically grown Egyptian cotton (*Gossypium barbadense*), sampled in 2008-2010.

Parameter	N	Minimum	Maximum	Mean	Standard deviation
C [%]	207	38.2	44.8	41.5	1.35
N [%]	207	2.68	5.43	4.13	0.51
P [g/kg]	205	1.42	5.47	3.32	0.78
S [g/kg]	207	5.23	14.8	8.78	1.62
K [g/kg]	207	14.1	54.9	30.3	7.21
Ca [g/kg]	207	12.8	45.9	26.8	6.07
Mg [g/kg]	207	3.87	9.50	5.84	1.00
Fe [mg/kg]	207	130	2,846	446	309
Mn [mg/kg]	207	20.1	165	60.7	22.5
Zn [mg/kg]	207	16	95.7	28.8	8.95
Cu [mg/kg]	207	7.01	20.9	12.1	2.29
B [mg/kg]	207	28.5	110	49.6	14.02
Mo [mg/kg]	207	0.62	3.80	1.87	0.82

Fig. 8.2 in the Appendix contains histograms of all plant parameters investigated in comparison to the normal distribution. Information on the degree of aberration from normal distribution is listed in Tab. 8.15 in the Appendix. The following distribution patterns can be distinguished:

- Approximate normal distribution: C, N, P, S, K;
- Distribution with a certain negative skewness, due to some outliers representing low concentrations: N;

- Distributions with a certain positive skewness, caused by a number of outliers with high concentrations: Fe, Mn, Zn;
- Distributions which show two more or less distinct maxima: Ca, Mg, Cu, B, Mo;
- C, N, K, Mo show a negative kurtosis (flatter curve than normal distribution), the other elements show a steeper than the normal distribution curve.

One reason for aberrations from the normal distribution might be found in the contamination with dust, which changed results of analyses for the various elements to different extents (see chapter 3.3.2).

4.3.2 Variation for different years and sampling regions

Analysing the effect of time and sampling region by two-way ANOVA (Tab. 4.4) clearly gives the result that, with the exception for Zn, there was a pronounced regional influence on the mineral composition of leaf tissue. In a number of cases, the year of sampling also had an influence on the composition of plant tissue (for C, N, Mg, Fe, Mn, Cu and Mo).

Tab. 4.4: Effect of region and year on the mineral composition of leaf tissue of organically grown Egyptian cotton sampled in 2008-2010, determined by two-way ANOVA.

Parameter	Year	Region	Year*region
C [%]	+	+	+
N [%]	+	+	+
P [g/kg]	-	+	+
S [g/kg]	-	+	+
K [g/kg]	-	+	+
Ca [g/kg]	-	+	+
Mg [g/kg]	+	+	+
Fe [mg/kg]	+	+	+
Mn [mg/kg]	+	+	+
Zn [mg/kg]	-	-	+
Cu [mg/kg]	+	+	+
B [mg/kg]	-	+	+
Mo [mg/kg]	+	+	+

(“+”=influence existing; “-“=influence not existing; p<0.05)

A certain variability with respect to the sampling region is also visible in the histograms of Fig. 8.2 in the Appendix, and from the information about deviations from the normal distribution, listed in Tab. 8.15 (Appendix).

4.3.3 Variation according to certification standards

The results of the one-way ANOVA of plant parameters with respect to the certification standard at the Beheira Governorate are displayed in Tab. 8.18 in the Appendix. According to this analysis, only for N and K there was a significant difference between the two groups ($p<0.05$).

4.4 Relation between soil and plant analysis data

4.4.1 Correlation analysis

In order to obtain some idea about the factors influencing yield level of organically grown cotton under the particular conditions of the Egyptian delta region, correlation analysis was applied. From Spearman's rho correlations, information on the percentage of explainable variation on relative yield by soil and leaf tissue concentration was extracted (Tab. 4.5).

Tab. 4.5 shows above all, that only a small proportion of yield variability is influenced by the factors investigated in this study: largest with almost 15 % was the influence of K_{CAL} in soils on the relative production. Concerning the soil parameters, among the macronutrients only the variability of potassium (K_{CAL} and K_{LE}) influenced the variability of relative yield by >10 %. Two of the analyzed phosphorus fractions (P_{H2O} and P_{Olsen}) showed an influence on yield variability <10 % and nitrogen of around 5 %. It is surprising, that secondary nutrients as well as micronutrients - with the exception of Mo - do not appear on this chart. Among non-nutritious elements, the variability of soil carbon influences the variability of relative yield to almost 10 % while variability of Al_{LE} and Na show a negative influence of below 10 %. Concerning plant parameters, only K and P showed a significant positive effect between 5 and 10 % on the variability of the yield while the variability of Fe and B had a negative effect of between 5 and 10 % on the yield variability.

Tab. 4.5: Percentage of variability of relative production explainable by variability of soil (a) and leaf tissue (b) parameters in organically managed cotton fields in Egypt in the years 2008-2010.

(a)		(b)	
Soil parameters	**Percentage of variability of relative yield explainable by variability of soil parameters**	**Plant parameters**	**Percentage of variability of relative yield explainable by variability of plant parameters**
K_{CAL}	14.4**	Fe	8.6**
K_{LE}	10.3**	K	9.0**
C_{total}	9.0**	P	6.3**
P_{Olsen}	7.6**	B	5.4**
P_{H2O}	6.2**		
Al_{LE}	7.7**		
C_{org}	7.5**		
N_{total}	5.6**		
Na	5.1*		

** p<0.01 (2-tailed); * p<0.05 (2-tailed); values highlighted in gray refer to negative correlation coefficients; all values not cited are below the lowest levels noted;

Tab. 4.6: Correlation between chemical parameters of soils under organically grown cotton in Egypt in 2008-2010.

	pH	C_{total}	C_{org}	$CaCO_3$	N_{total}	P_{H2O}	P_{CAL}	P_{LE}	P_{Olsen}	S_{LE}	K_{CAL}	K_{LE}	CA_{LE}	$Mg_{Schacht}$	Mg_{LE}	Fe_{LE}	Mn_{LE}	Zn_{West}	Zn_{LE}	Cu_{West}	Cu_{LE}	B_{LE}	Mo_{LE}	Na	el. Cond.
C_{total}	-○																								
C_{org}	-●	⓿																							
$CaCO_3$		⓿																							
N_{total}	-●	⓿	⓿																						
P_{H2O}		○																							
P_{CAL}	-●	○	○		●	●																			
P_{LE}	-○			-○		●	●																		
P_{Olsen}	-○	●	●	○	●	●	⓿	○																	
S_{LE}				○		-●		○	○																
K_{CAL}	-○	⓿	●	●	●	●	●		⓿																
K_{LE}	-○	⓿	●	●	●	●	●		⓿		⓿														
CA_{LE}		⓿	○	⓿	○		○		●	●	●	●													
$Mg_{Schacht}$		-○		-○		-●				○	-○	-○	-○												
Mg_{LE}						-○		-●		●			○	⓿											
Fe_{LE}				-●		-○			○	○	-○		-○	●	●										
Mn_{LE}	-○	○			○	○	●	●	○	-○		○		-○	-○										
Zn_{West}		-●		-⓿				●	-○	-●	-○	-○	-⓿		-⓿		●								
Zn_{LE}	-●	○	●		●	○	●	⓿	●		○	●					●	⓿							
Cu_{West}		-●		-⓿				●	-○	-●	-○	-○	-⓿		-⓿		●	⓿	●						
Cu_{LE}	-●		●	-○	○	○	○	●	○	-○			-○			●	○	⓿	●	⓿					
B_{LE}		⓿		⓿			●	-●	⓿	⓿	⓿	⓿	⓿	○	⓿		-●	-●		-●					
Mo_{LE}		⓿	○	⓿	○		○	-●	●	⓿	●	●	⓿		○			-●	○	-⓿	-○	⓿			
Na		○		⓿			●	-○	●	⓿	○	○	●	●	⓿	○	-●	-●	-○	-○		⓿	●		
el.Cond.	-○	●		⓿			●	-●	●	⓿	●	●	⓿	●	⓿	○	-●	-●	-○	-●		⓿	●	⓿	
Al_{LE}		●	-○	-●	-○	-○			-○	-○	-●	-○	-⓿	●	○	●	-○				○		-⓿		

Spearman's rho correlation, 2-tailed, p<0.01 level; "○"= 0.2<correlation coefficient < 0.4; "●"= 0.4<correlation coefficient<0.6; "⓿"= correlation coefficient >0.6; "-"=negative correlation coefficient;

Tab. 4.7: Percentage of variability of nutrient concentrations in young, fully matured main stem leaves of organically grown cotton explainable by variability of soil parameters grown in Egypt in the years 2008-2010.

Soil- / Plant parameters	Percentage of variability of plant constituent explainable by variability of soil parameters
K_{CAL} /K	21.2**
Ca_{LE} / Ca	19.4**
K_{LE} / K	16.8**
Zn_{West} / Zn	14.7**
Cu_{West} / Cu	7.2*
Cu_{LE} / Cu	4.5**
P_{Wa} / P	3.8*
P_{Olsen} / P	3.6**

**p <0.01 (2-tailed); * p <0.05 (2-tailed); all values not cited are below the lowest levels noted;

The variability of only a few macronutrients in soil showed an influence >10 % on the variability of the corresponding plant nutrient concentration (Tab. 4.7): these are both fractions of K analyzed as well as Ca. The influence of water- and $NaHCO_3$-extractable phosphorus on plant P-variability is below 5 %. Variability of N and S in soils does not seem to influence their corresponding concentration in plant tissue. Concerning micronutrients, Zn_{West} in soils shows with ca. 15 % the highest influence on the variability of Zn-concentration in plant tissue, followed on a lower level by Cu_{LE} and Cu_{West}.

In Tab. 4.7, the relations between different soil constituents are depicted. It can be summarized, that with rising pH-level, a number of minerals (N, P, K, Mn, Zn and Cu) show reduced solubility. The positive correlation between C_{total}, respectively C_{org} and a range of nutrients is due to the soil organic matter, which furnishes as source of nutritious minerals. Negative correlation between $CaCO_3$ and P, Mg, the micronutrients Fe, Zn and Cu and with Al is due to the fixation of these elements as carbonates. High positive correlations of B, Mo, Na and the parameter electrical conductivity exist to $CaCO_3$, S_{LE}, Ca_{LE} and both fractions of Mg. This can be interpreted – at least with reference to the coastal regions - as indication of a marine influence. Zn, Cu and Mn, on the other hand, show high negative correlations to B, Mo, Na and electrical conductivity. Fe and Al are positive correlated and show negative correlations with a number of other elements. Na and electrical conductivity are in a number of cases positively correlated with other soil parameters and show only negative correlations with P_{LE}, Mn, Zn and Cu.

Tab. 4.8 gives an overview over the correlations between soil and plant analysis parameters. Only correlations which are significant at the 0.01-level are listed in the table. Most of the indicated correlations range between 0.2 and 0.4, i. e. between 4 % and 16 % of the variability of plant parameters are explainable by variability of soil parameters. Only a few correlations reach values above this level.

Almost no significant correlations were found with the pH-level of the soil, which is surprising, as the availability of micronutrients usually decreases with rising pH-level. Organic carbon, which is representative for soil organic matter, only shows a positive correlation with Mo, but a negative correlation with Mn and B. Negative correlations with plant parameters show in most of the cases $Mg_{Schacht}$, Fe_{LE} and Al_{LE}. Salinity, which is measured by electrical conductivity and the concentration of

Na in soil, does not correlate with many plant parameters. Only K, Ca, Zn and Cu show a significant correlation between soil parameters and corresponding plant values with a correlation coefficient of >0.2.

Tab. 4.8: Correlation between plant- and soil analysis data of organically grown cotton (*Gossypium barbadense*) in Egypt in 2008-2010.

	Soil parameters																								
Plant parameters	pH	C_{total}	C_{org}	$CaCO_3$	N_{total}	P_{H2O}	P_{CAL}	P_{LE}	P_{Olsen}	S_{LE}	K_{CAL}	K_{LE}	Ca_{LE}	$Mg_{Schacht}$	Mg_{LE}	Fe_{LE}	Mn_{LE}	Zn_{West}	Zn_{LE}	Cu_{West}	Cu_{LE}	B_{LE}	Mo_{LE}	Na	el. conductivity	Al_{LE}
N						○		○																		
P				-○					○					○	○	●					○					
S		○		○							○	○		-○	-○	-○										-○
K		●									●	●	○	-○		-○										-○
Ca	-○	●		●					○		○		●	-●		-●						○		○	○	-○
Mg																										
Fe		-○				-○		-○			-○	-○		○				-○				○		○	○	
Mn	○		-○						-○					-○	-○	-●					-○	-●		-●	-●	
Zn				-○				○						-○			○	○				-○			-○	-○
Cu						○		●						-○				○			○	-○				-○
B			-○	○				-○					○	-○		-○					-○					
Mo		●	○	●	○	○					○	○	○			-●										-○

Spearman's rho correlation, 2-tailed, $p<0.01$; "○"= 0.2<correlation coefficient < 0.4; "●"= correlation coefficient>0,4; "-"=negative correlation coefficient;

4.4.2 Multiple regression analysis

In order to obtain a better understanding of the soil→plant relationships, stepwise multiple regression analysis of relations between plant tissue concentrations of Egyptian cotton and corresponding soil analysis data was undertaken. In the table below (Tab. 4.9), the results are summarized: after regression analysis failed in most cases for the corresponding soil nutrient, "classical" factors influencing the plant concentration of a nutrient were tested, such as pH-value, C_{org} (as representative for soil organic matter), $CaCO_3$ (as it chemically bonds a number of elements). After that, all soil parameters were tested: together with the pH-value and Mg, in many cases micronutrients (Cu, Zn, Mn, Fe and B) and Al, only in two cases Na were the soil elements accepted as best fitting factors (i. e. resulting in a high r^2-value).

Tab. 4.9: Results of multiple regression analysis of relations between plant tissue concentrations of Egyptian cotton and corresponding soil analysis data (2008-2010).

Parameter	Variables	r^2	F	p
N	Cu_{West}, pH	0.216	6.481	0.003
P	Fe_{LE}	0.151	29.14	0
S	Mn, Na	0.415	16.654	0
K	Fe_{LE}, N, P_{Olsen}, Al_{LE}	0.51	11.714	0
Ca	pH, Na	0.267	8.545	0.001
Mg	pH, $Mg_{Schacht}$, Cu_{West}, Al_{LE}	0.476	10.23	0
Fe	pH, Mg_{LE}, KCAL	0.406	10.466	0
Mn	Mn_{LE}, Cu_{LE}, S_{LE}, Zn_{LE}, $Mg_{Schacht}$	0.559	11.166	0
Zn	pH, Mn_{LE}, $Mg_{Schacht}$	0.247	5.038	0.004
Cu	B_{LE}	0.084	4.653	0.36
B	Cu_{LE}, Zn_{LE}, Al_{LE}, Ca_{LE}	0.541	13.268	0
Mo	Fe_{LE}, P_{Olsen}, Zn_{LE}	0.51	15.952	0

At this point it can be concluded, that only limited information could be deduced from nutrient concentrations in soils for the nutrient supply of plants. Only for the two elements K and Ca, highly significant ($p<0.01$) and strong correlations existed between soil concentration and plant supply. In all other cases, the correlations were weaker ($Zn\text{-}Zn_{West}$ and $Cu\text{-}Cu_{LE}$) or less significant respectively non-existent. Obviously, there was a strong interdependency of soil parameters, which can result in inhibition of plant uptake of one nutrient in the presence of another (i. e. effect of salinity).

Moreover, the results of the preceding chapters show, that

- soil nutrient concentrations were heterogeneous and did not follow a normal distribution over all sampling sites, therefore a statistical evaluation was difficult.
- plant concentrations were more homogenous and exhibit a better accordance with a normal distribution.
- soil /plant correlations did not give sufficient information on the nutrient supply status of the cotton crop.

Therefore critical values as target- and control values for fertilization measures respectively soil amendment measures should be deduced preferably from plant concentrations.

4.5 Relation between mineral element concentration in plant leaves and yield

The primary aim of the present research work was to elaborate critical values for organically grown cotton in Egypt according to the boundary line method and to compare these target values with values deduced by other methods.

4.5.1 Deduction of critical values according to Walworth and Sumner (DRIS)

Mean values, standard deviations and coefficients of variation were determined for the best 15 % of all farms as explained in chapter 0. and listed in Tab. 8.20 in the Appendix. Mean values, standard deviations and coefficient of variation are listed in Tab. 4.10. In chapter 5.1.3, data will be further evaluated.

Tab. 4.10: Mean values, standard deviations and coefficients of variation for the 15 % best performing producers of organic cotton (*Gossypium barbadense*) in Egypt.

	rel. Prod.	C	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo
	[%]			[g/kg]					[mg/kg]					
μ^1	120.4	41.0	3.6	3.6	9.3	35.5	26.9	5.9	364	55.6	31.5	13.0	46.6	1.9
σ^2	6.4	1.0	0.8	0.8	1.4	6.3	7.6	1.0	265	22.5	8.0	2.8	13.3	0.7
c_v^3	5.3	2.3	20.8	20.8	14.9	17.7	28.1	16.7	72.9	40.5	25.4	21.4	28.6	37.0

[1]mean values, [2]standard deviation, [3]coefficient of variation $[(100*\sigma)/|\mu|]$

4.5.2 Deduction of critical values according to Cate and Nelson

The deduction of critical values according to Cate and Nelson (1971) was tested exemplarily for phosphorus, boron and iron, but failed. Tab. 8.21 in the Appendix shows the calculation exemplarily for phosphorus. No effort was undertaken deduce critical values for further elements with this method. In chapter 5.1.2, the failure of this method with respect to the analysis of the presented data set will be further discussed.

4.5.3 Deduction of critical values according to Khiari et al.

While Parent and Dafir (1992) used a fixed cut-off level to separate low and high yielding subpopulations and calculate mean critical values from the high yielding subgroup, Khiari et al. (2001a) introduced the cumulative variance ratio function and used the inflection point in the graph of this function – a polynomial of 3rd degree – for the separation of the two subpopulations (Tab. 8.22 and Fig. 8.4, Appendix). This method applied to the given data set resulted in separation points at yield levels between 71 % (for zinc) and 110.4 % (for magnesium). The first goes along with a cut-off percentage for the high yielding subpopulation of 97.6 % and the second of 19.7 %. At least when using polynomials of 3rd degree to fit the data of the cumulative variance ration function, as proposed by the authors, the determination of the cut-off point leads to a wide range of values with a far too large percentage of best performers (Tab. 4.11).

These results, which will be further discussed in chapter 5.1.2, were the reason why in the present evaluation, for further calculations of CND-values, the cut-off point was fixed to the upper 15 % best producers. An advantage of this proceeding is that a comparison between data evaluations according to CND and DRIS can be performed more easily.

Tab. 4.11: Inflexion points of cumulative variance ratio functions according to Khiari et al. (2001a) as cut-off values between low and high yielding fractions of a population of organically grown cotton in Egypt.

Element	x-value for separating high and low yielding varieties	Percentage of population covered by high yielding variety
N	96.8	62.5
K	98.6	58.7
S	94.7	66.4
Mg	110	19.7
Zn	71	97.6
Cu	102	48.1
B	101	50.5
Mo	98.9	57.7

4.5.4 Deduction of critical values with the boundary line method

Critical values and sufficiency ranges were calculated as explained in chapter 3.4.3. In Tab. 4.12, the equations of the best fitting boundary line function for each element, expressed as polynomials of 2nd or 3rd order, the determined critical values (for maximum yield) and corresponding sufficiency ranges (referring to 95 % of maximum yield) are listed. Additionally, a validity range for the boundary line equation is added: the lower end of the validity range is defined as lowest nutrient level not excluded as outlier, the upper end of the validity range is defined as the upper end of the sufficiency range.

Critical values were determined for all macro-, secondary- and micronutrients discussed and, additionally, for carbon. In order to choose the best fitting boundary line, polynomials of the 2nd, 3rd and 4th degree were calculated for each element in order to fit the step functions deduced from the scatter diagrams plant tissue concentration / relative yield (Fig. 8.5, Appendix). On the left side of Fig. 8.5, each polynomial is shown in relation to the reduced data set (outliers removed) and with the lines of the step function added. On the right side, the same polynomial is shown in relation to the original data set, outliers marked in magenta. All elements expressing a fairly normal distribution of their leaf concentration (see chapter 4.3.1) exhibit an acceptable polynomial fitting curve. If a good fitting of the curve especially with respect to the right side of the scattered points (which represent low plant concentrations) could be achieved, a lower polynomial degree was preferred to a higher one, especially as polynomials of the 4th degree tend to produce graphs tha flutter at the sides.

Good fittings could be achieved for the macronutrients N, P, the secondary nutrients Ca, Mg and the micronutrients Zn, Cu, Mn and Mo. For those elements, which exhibit aberrations from the normal distribution, it turned out to be difficult to achieve a satisfactory fitting with the boundary line: This was the case for the elements K and S among the macro- and secondary elements and for B and Fe among the micronutrients (Tab. 4.7). These elements show a pronounced positive skewness in their distribution (Fig 8.2, Appendix), a number of outliers respectively in the case of B, a second maximum. Fe possibly exhibits higher concentrations due to superficial pollution of the leaves (see chapter 3.3.2, Tab. 3.3). In the case of S, no further adaption of the data was executed but in the case of K, the number of outliers to be removed from the basic data set of 207 was increased to 58 (in comparison to 8 respectively 18 in the other cases).

Concerning Fe and B, the extent of superficial pollution was estimated in dependence of the results of the corresponding pre-test (Tab. 3.3). In the case of B, the highest 34 values were eliminated before establishing the boundary line and in the case of Fe the 61 highest values.

Tab. 4.12: Boundary line functions, critical values, sufficiency ranges and validity ranges for nutrient concentrations in young, fully matured main stem leave blades of organically grown Egyptian cotton (*Gossypium barbadense*), sampled in 2008-2010.

Plant constituent [dimension]	Boundary line function	Critical value	Sufficiency range (95 % yield), corresponding yield	Validity range
N [g/kg dm]	$f(x)= -306.5+209\,x-25.3\,x^2$	4.1	(3.6, 122.0) ≤ yield ≤ (4.6, 122.0)	2.9 ≤ N ≤ 4.6
P [g/kg dm]	$f(x)=26.8+57.2x-8.46x^2$	3.4	(2.5, 117.5) ≤ yield ≤ (4.2, 117.5)	1.4 ≤ P ≤ 4.2
S [g/kg dm]	$f(x)=-63.4+42.0x-2.36x^2$	8.9	(7.4, 116.9) ≤ yield ≤ (10.5, 116.9)	5.2 ≤ S ≤ 10.5
K [g/kg dm]	$f(x)=-26.4+9.24x-0.15x^2$	30.6	(24.5, 109.3) ≤ yield ≤ (36.8, 109.3)	14 ≤ K ≤ 36.8
Ca [g/kg dm]	$f(x)=12.1+8.03x-0.15x^2$	26.8	(20. 7, 113.7) ≤yield≤(33.1, 113.7)	16.2≤Ca≤33.1
Mg [g/kg dm]	$f(x)=-96.3+74.6x-6.41x^2$	5.8	(4.9, 115) ≤ yield ≤ (6.8, 115)	4≤Mg≤6.8
Fe [mg/kg dm]	$f(x)=-65.8+1.6x-0.004x^2+3.15*10^{-6}x^3$	272.6	214, 119.3) ≤ yield ≤ (354, 119.3)	167≤ Fe ≤ 354
Mn [mg/kg dm]	$f(x)=15.6+4.72x-0.065x^2+0.0003x^3$	54.2	(39, 116.8) ≤ yield ≤ (72.8, 116.8)	20.3 ≤ Mn ≤ 72.8
Zn [mg/kg dm]	$f(x)=-221.997+34.396x-1.128x^2+0.012x^3$	25.1	(21, 111) ≤ yield ≤ (30.9, 111}	19.2 ≤ Zn ≤ 30.9
Cu [mg/kg dm]	$f(x)=-309.9+97.55x-7.13x^2+0.17x^3$	11.1	(9.4, 113.5)≤yield≤(13.3, 113.5)	8 ≤ Cu ≤ 13.3
B [mg/kg dm]	$f(x)=-153.2+12.49x-0.14x^2$	44.5	(37.9, 118.7) ≤ yield ≤ (51.2, 118.7)	32.7 ≤ B ≤ 51.2
Mo [mg/kg dm]	$f(x)=26.3+156.8x-72.3x^2+9.61x^3$	1. 6	(1.1, 124. 9) ≤ yield ≤ (2.1, 124.9)	0.63 ≤ Mo ≤ 2.1
C [%]	$f(x)=-5820.5+285.7x-3.43x^2$	41.6	(40.3, 118.6) ≤ yield ≤ (43, 118.6)	39 ≤ C ≤ 43

Variation in different years

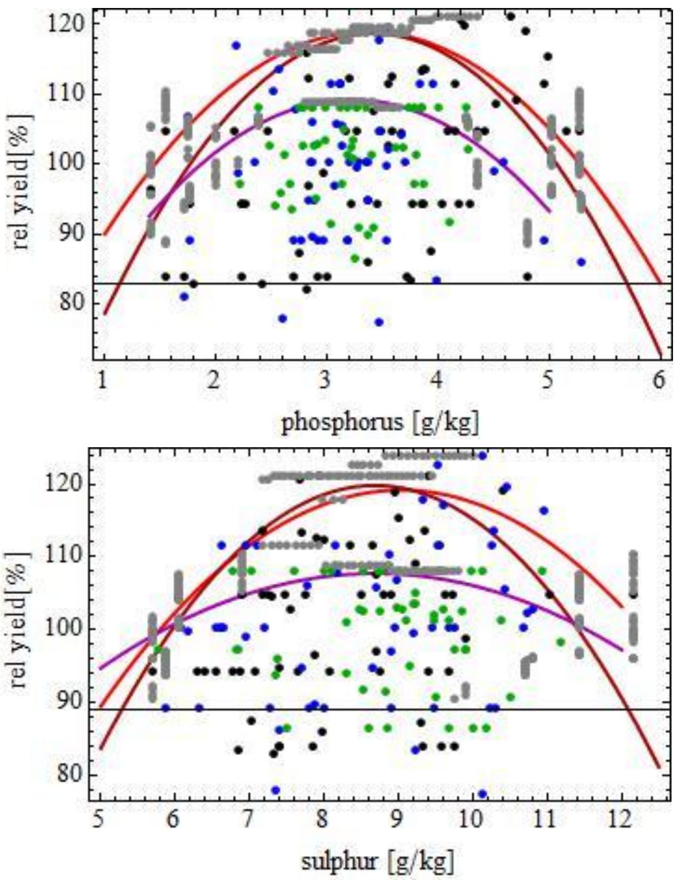
Boundary line functions and critical values were also calculated for all elements with respect to the year of sampling, except for Fe, and Mn, as the large proportion of outliers concealed a yearly difference. The manual elimination of outliers before establishing the boundary line would signify a strong manipulation of the procedure (small group size with different sizes for each year).

All graphs deduced are assembled with the relating information in Fig. 8.6 in the Appendix. The following general patterns can be distinguished:

The shape of the boundary lines deduced differed between the years: obviously, the variance for a range of elements (S, K, C, Mg, Zn, Mo, C) was larger in 2010 than in 2008 and 2009. This goes along with a lower relative yield in 2010 and results in a flatter boundary curve in this year than in the preceding years.

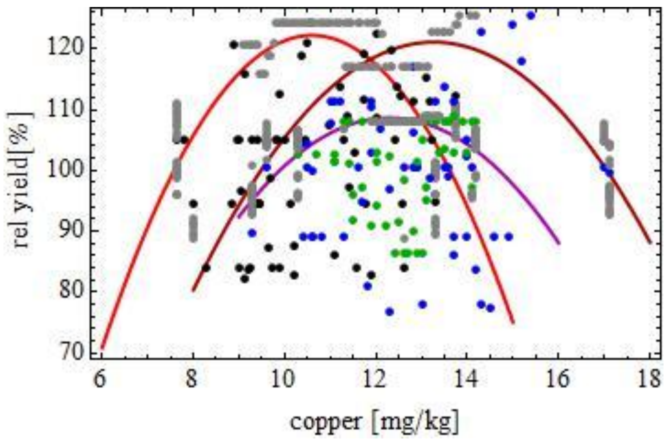
Consistency of critical values over all three sampling years: this could be observed for N, P, S, K, Ca, Mn, Zn and B. If the same values were determined with a certain continuity in the past, there is a high probability, that they are also valid in the future (Fig. 4.5).

Critical values were different for the three sampling years: this was the case for Mg, Cu and Mo and is shown for Cu and Mo in Fig. 4.6. As far as Cu is concerned, critical values increased in the order 2008>2010>2009 and for molybdenum in the order 2008>2009=2010. It is possibly that climatic influences are responsible for these variations, but further investigations on influencing factors are needed.



2008=black points, red line, 2009=blue points, dark red line, 2010=green points, lilac line

Fig. 4.5: Scatter diagrams and boundary lines for plant tissue samples of *Gossypium barbadense* differentiated according to the year of sampling for the plant nutrients phosphorus and sulfur.



2008=black points, red line, 2009=blue points, dark red line, 2010=green points, lilac line

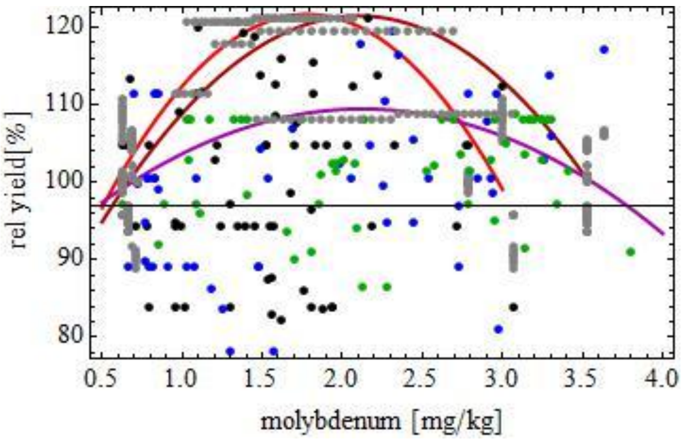
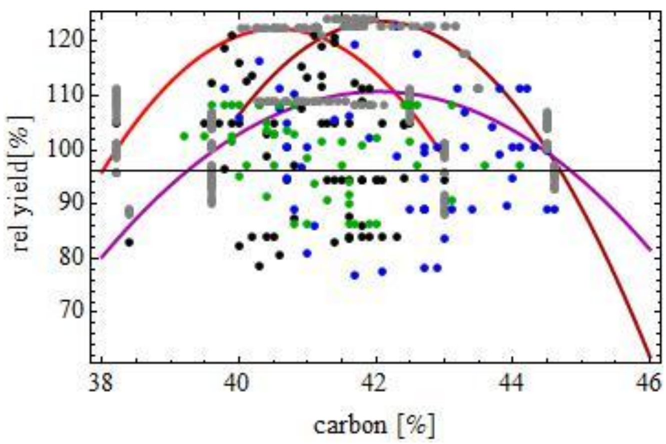


Fig. 4.6: Scatter diagrams and boundary lines for plant tissue samples of *Gossypium barbadense* differentiated according to the year of sampling for the plant nutrients copper and molybdenum.

Concerning carbon, a critical value was determined with respect to the three sampling years, as an indication for water shortages respectively salt stress: carbon values were considerably lower in 2008 than in 2009 and 2010, which implies, that climatic influences were possibly stronger in the last two years of the present investigation. Especially in 2010, C-concentrations spread (large standard deviation), which indicates a large variability of the boundary line and in consequence a large variability in the extent of water- and salt stress over the different sampling sites (Fig. 4.7).



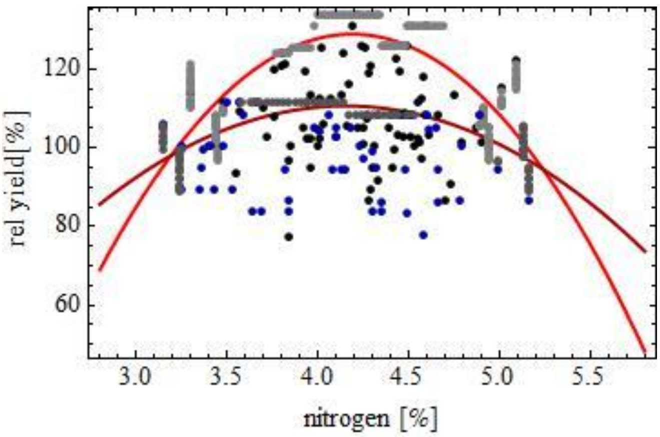
2008=black points, red line, 2009=blue points, dark red line, 2010=green points, lilac line

Fig. 4.7: Scatter diagrams and boundary lines for plant tissue samples of *Gossypium barbadense* differentiate according to the year of sampling with respect to the plant carbon concentration.

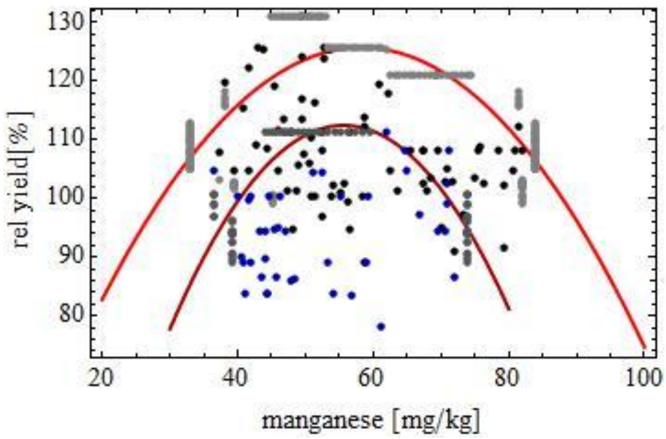
Regional variation

In order to evaluate the influence of the sampling region for the establishment of critical values by means of the boundary line method, boundary line functions, critical values and sufficiency ranges were calculated separately for the Beheira and Sharkia governorate, which were the two sampling regions for which sufficient number of samples were collected in order to deduce critical values using the boundary line method. Beheira (W and O) is the sampling region where the highest yields were achieved (see chapter 4.1), in Sharqia (W and O) the yield levels attained are lower and comparable to the levels at the other sampling regions. All graphs and data are listed in Fig. 8.7, Appendix. The following general patterns can be distinguished:

Critical values were about the same at the Beheira (high yielding) and Sharqia (low yielding) governorates: this was the case for nitrogen, magnesium, manganese, zinc, boron (Fig. 4.8):



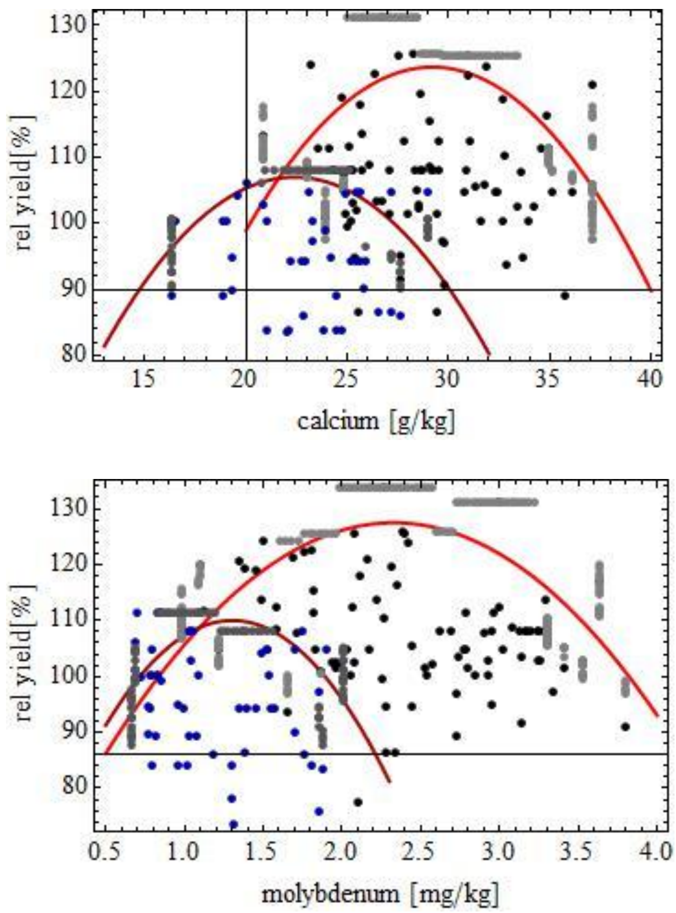
Beheira=black points, red line, Sharqia=blue points, dark red line



Beheira=black points, red line, Sharqia=blue points, dark red line

Fig. 4.8: Scatter diagrams and boundary lines for plant tissue samples of *Gossypium barbadense* from two different sampling regions for the plant nutrients nitrogen and manganese.

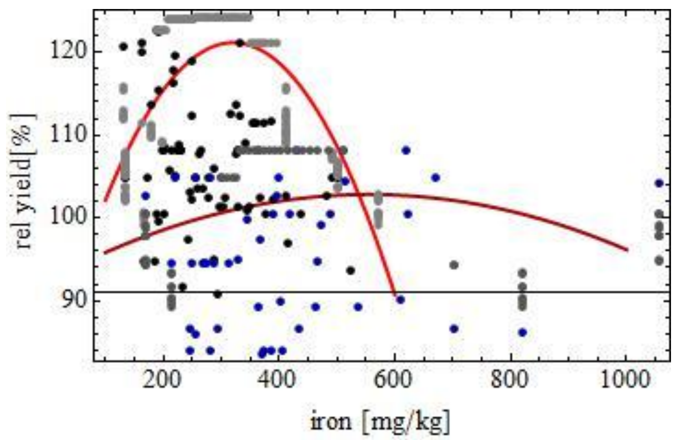
Critical values were higher at Beheira (high yielding) and lower at Sharqia (low yielding): this was the case for sulfur, potassium, calcium, copper and molybdenum. These elements therefore were possibly in need at Sharqia (Fig. 4.9).



Beheira=black points, red line, Sharqia=blue points, dark red line

Fig. 4.9: Scatter diagrams and boundary lines for plant tissue samples of Gossypium barbadense from two different sampling regions for the plant nutrients calcium and molybdenum.

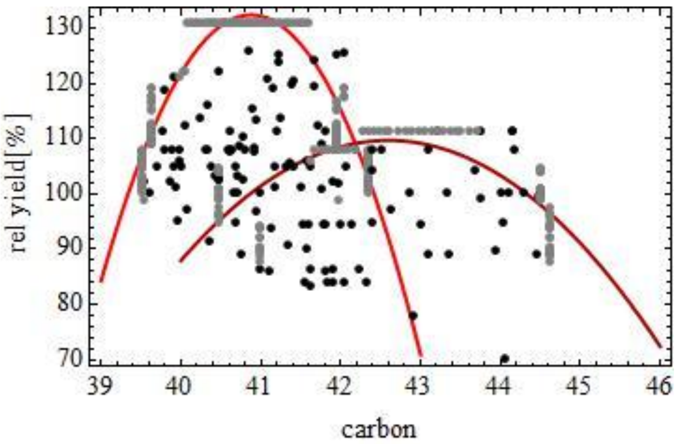
Critical values were lower at Beheira (high yielding) and more elevated at Sharqia (low yielding): this was the case for Fe (and for P, to a very small extent). At Sharqia, values for Fe were broadly scattered (even if a large number of outliers were eliminated). The explanation of this phenomenon only with contaminations of leaf surfaces does not seem logical, as they do not occur to the same extent at Beheira Governorate. Futhermore, there is the pronounced yield effect to be considered (Fig. 4.10).



Beheira=black points, red line, Sharqia=blue points, dark red line

Fig. 4.10: Scatter diagrams and boundary lines for plant tissue samples of Gossypium barbadense from two different sampling regions for the plant nutrient iron.

Boundary lines were also constructed for carbon concentration of *Gossypium barbadense*. The critical value for carbon in cotton plants grown at the Beheira governorate were almost 2 % points lower than the ones at Sharqia. This is a clear indication towards problems with water supply and salt stress at Sharqia governorate (Fig. 4.11).



Beheira=black points, red line, Sharqia=blue points, dark red line

Fig. 4.11: Scatter diagrams and boundary lines for plant tissue samples of *Gossypium barbadense* from Beheira (black points, red line) and Sharqia (blue points, dark red line) for carbon.

4.6 Evaluation of cotton leaf tissue analyses

An aim of the present study is to evaluate the individual nutrient status of the cotton crop *(Gossypium barbadense*) at different sites of the Nile Delta and Faiyum. Along with this evaluation goes the aim to compare results gained by the PIPPA-method, which employs the equations of the boundary lines (see Tab. 4.13) in order to calculate deficiencies with the main competing evaluation methods, DRIS and CND.

For this purpose, for all 207 data sets of the samples included in the present study, indices according to the specifications of PIPPA, DRIS and CND were calculated, using the results of cotton leaf tissue analyses for the minerals N, P, S, K, Ca, Mg, Fe, Mn, Zn, Cu, B and Mo.

4.6.1 Evaluation according to PIPPA-method

Indices according to the Professional Interpretation Program for Plant Analysis (PIPPA) (Schnug, 1990) were computed as explained in the chapters 2.3.1 and 3.4.5, PIPPA indices for all investigated farms and all years and are listed in Tab. 8.23 in the Appendix. Using the univariate approach, PIPPA-indices were calculated nutrient by nutrient from the results of chemical analysis of individual plant tissue samples. They represent potential yield reductions due to the deficiencies of plant nutrients analysed: the higher the percentage of yield reduction, the stronger the need of the plant for the corresponding nutrient. In Fig. 4.12, PIPPA-indices are visualized as stapled bar charts with respect to each sampling site (indicated as farm number) and differentiated for each year of sampling (indicated as figure following the farm number) and the sampling region (indicated as abbreviation). The longest bar sector represents the nutrient with the largest yield limiting power. According to Liebig's Law it is essential to eliminate the strongest yield limiting element first in order to improve crop growth (Schnug and Haneklaus, 2008a). Fig. 4.12 clearly visualizes the predominance of a characteristic range of deficient minerals at different sampling regions:

- At the western Beheira (Beheira-W) governorate, Fe was diagnosed the most needed element in cotton leaf tissue, followed by Mg. In general, deficiencies were detected on a very low level. At the eastern Beheira (Beheira-O) governorate, there were a few plants with more serious deficiencies detected in 2008, a diagnosis which could not be repeated in the two following years. Besides for Fe, quite a number of cotton plants were diagnosed deficient for the micronutrients Mn, Cu, B and Mo. Only in a few cases, there was a minor need for N and P.
- At Dakahlia and Damietta - especially in 2010 - N, K, Mn and Mo were particularly in need.
- Cotton plants from western Sharqia (Sharqia-W) reveal quite a uniform pattern of deficiencies: many plants show a strong need for S, K, Ca, B and Mo. A number of plants additionally show deficiencies of N and Cu. Plants from the eastern Sharqia governorate (Sharqia-O) revealed an even more homogenous diagnosis: again, S, K, Ca and Mo are in need. In a number of cases, N, P, Cu and Zn were also diagnosed as deficient.
- At Qalyubia, K, P, S and Mo are the nutritious elements mostly in need.
- Concerning the farms at Faiyum oasis, deficiencies were diagnosed as follows: most in need was P and Cu, in a number of samples also deficiencies of Mg, N and K were diagnosed.

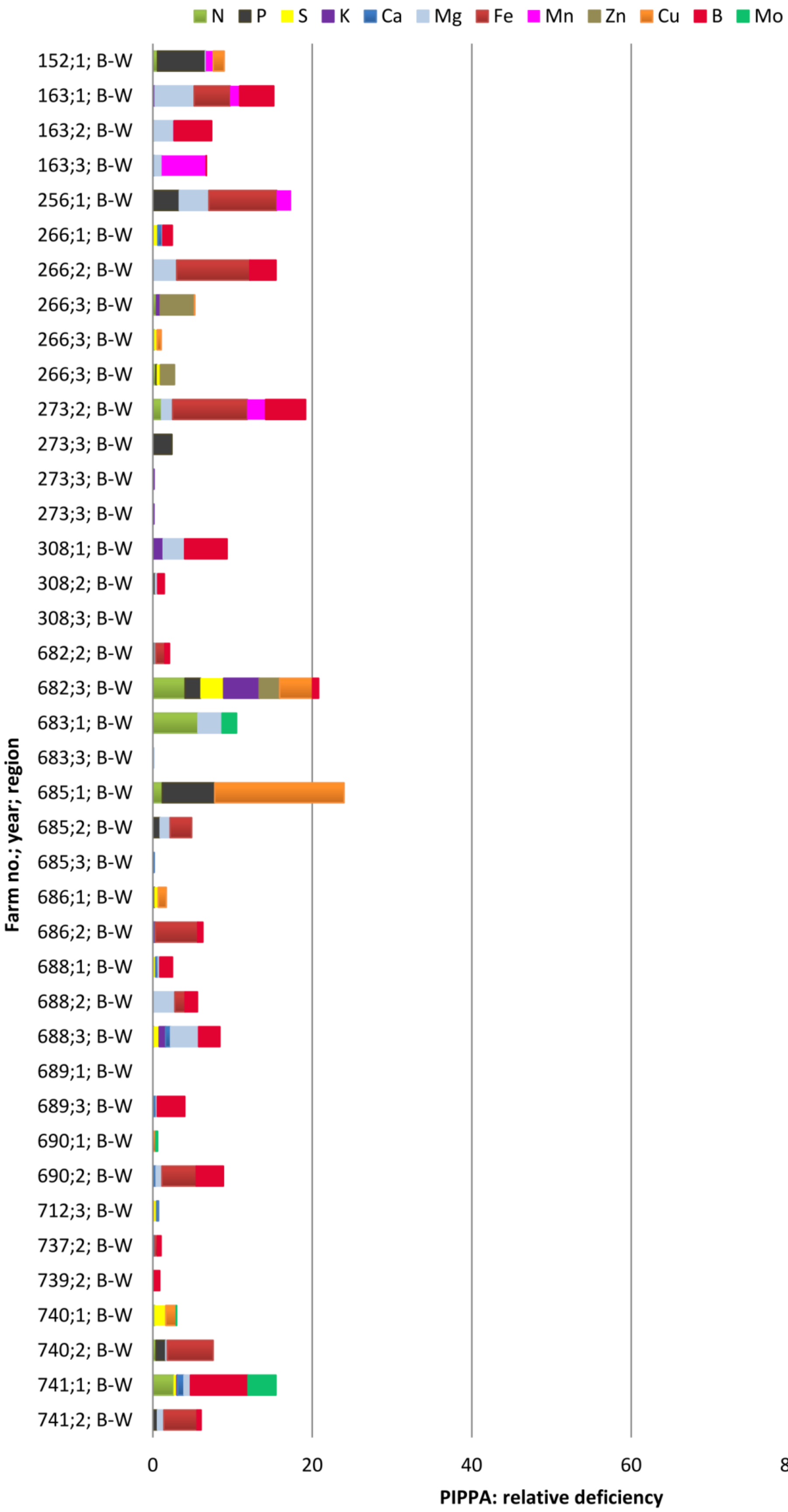


Fig. 4.12: Relative nutrient deficiencies diagnosed according to Professional Interpretation Program for Plant Analysis (PIPPA) (Schnug, 1990) in young, fully developed main stem leaf blades of organically grown cotton (*Gossypium barbadense*), sampled in 2008-2010.

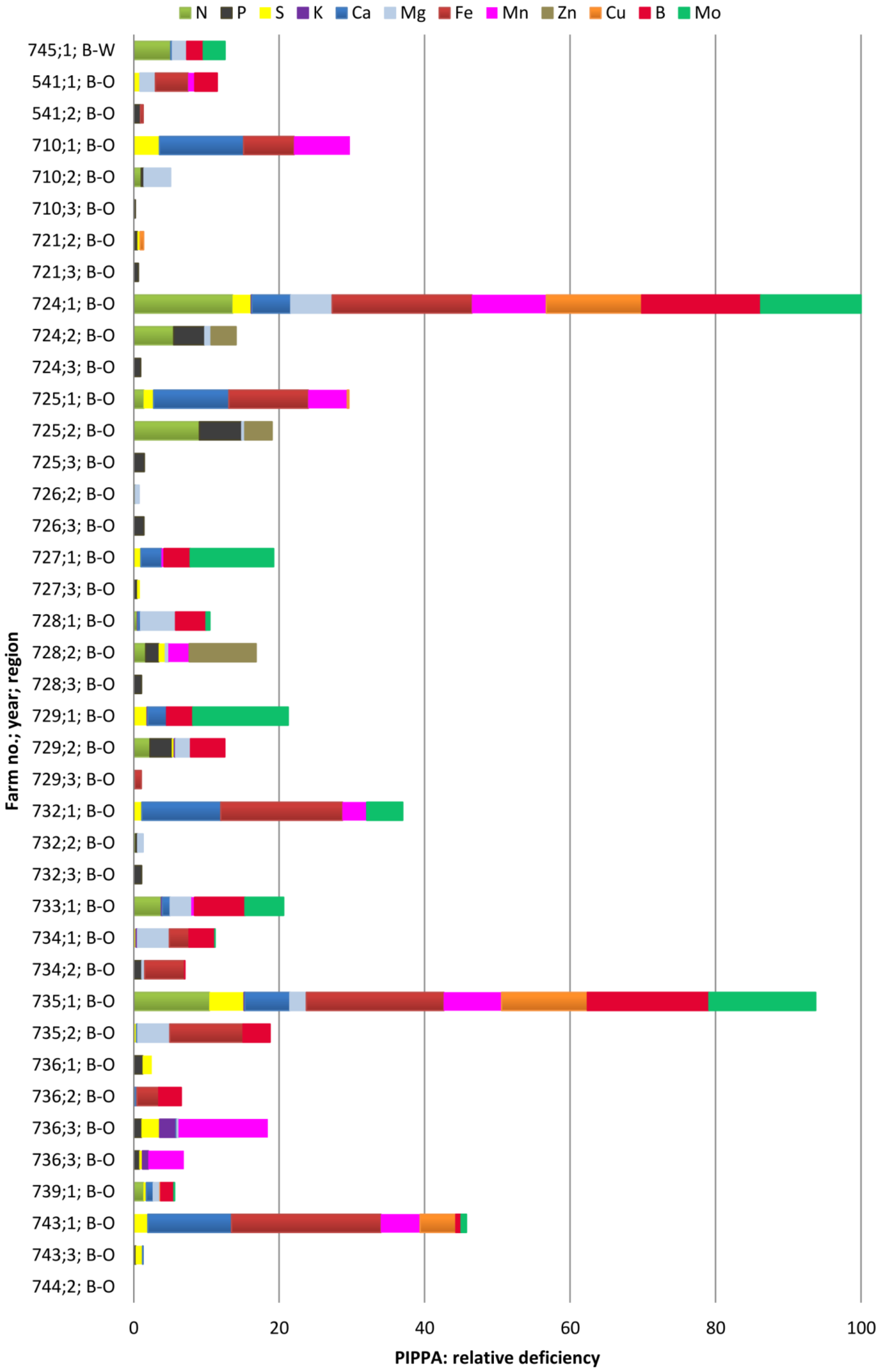


Fig. 4.12 continued; Year: 1=2008, 2=2009, 3=2010; region: B-W=Beheira-west, B-O=Beheira-east, S-W=Sharqia-west, S-O=Sharqia-east, Dah=Dakahlia/Damietta, Qal=Qalyubia, Fai=Faiyum.

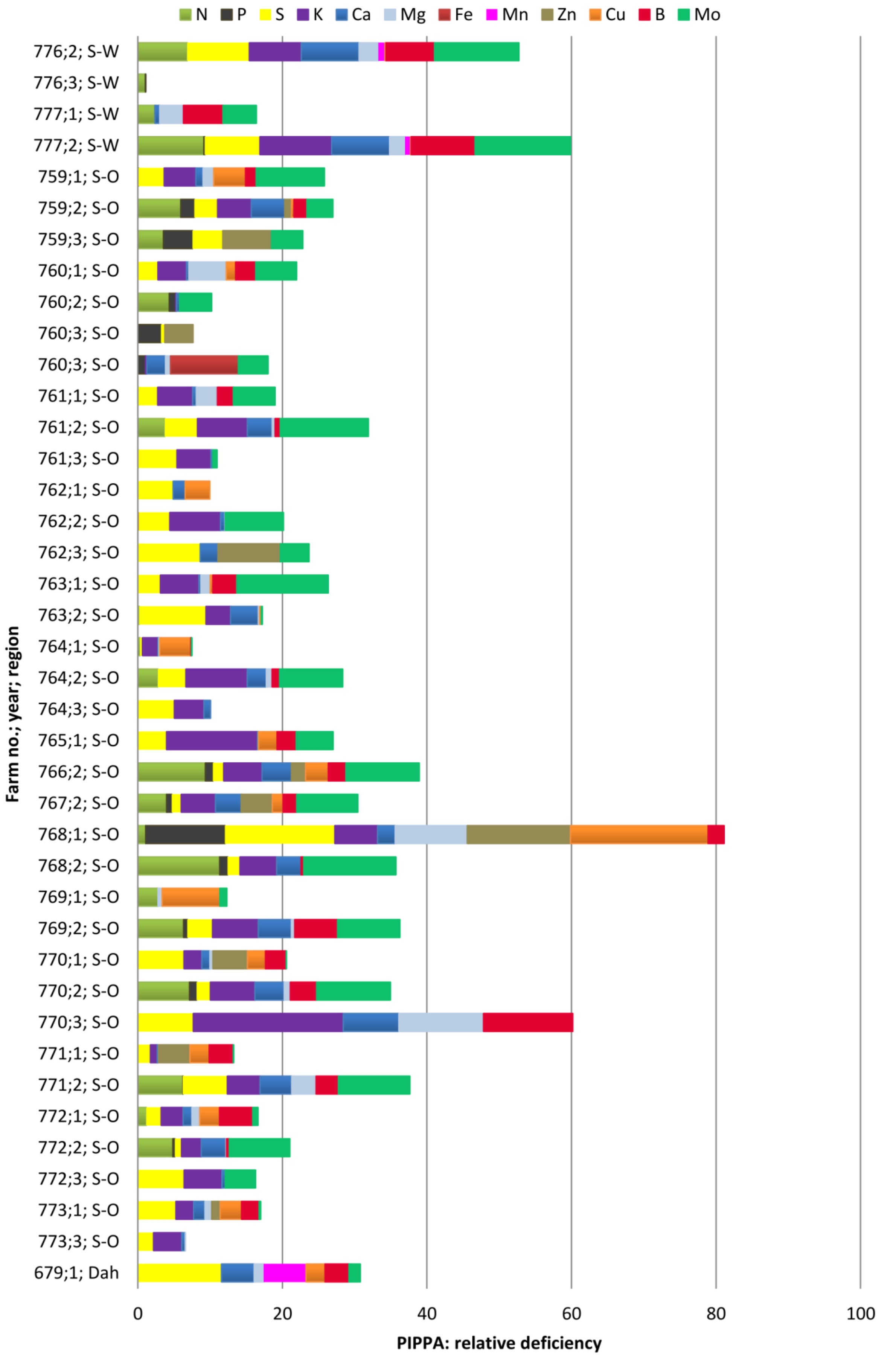


Fig. 4.12 continued

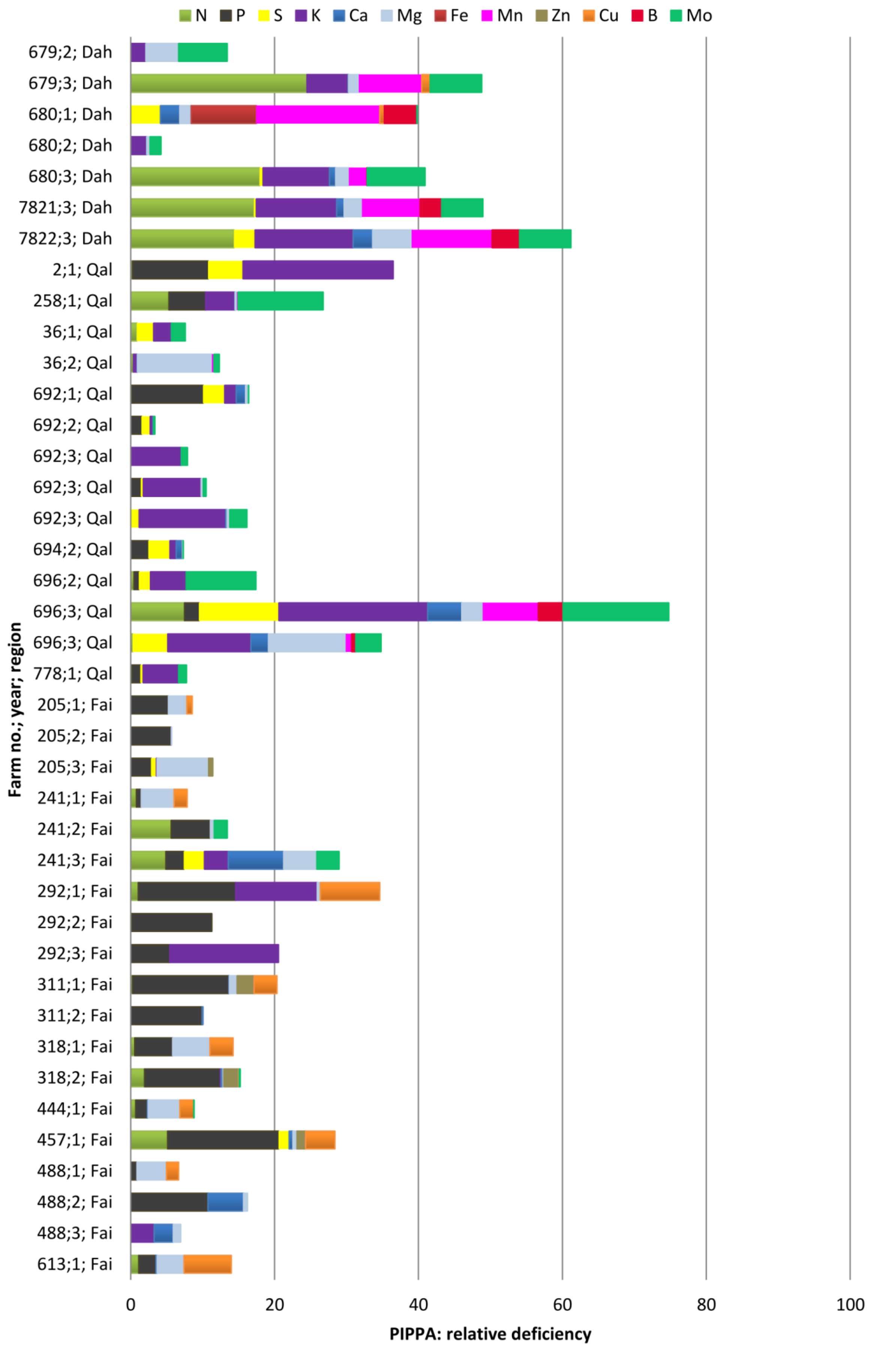


Fig. 4.12 continued

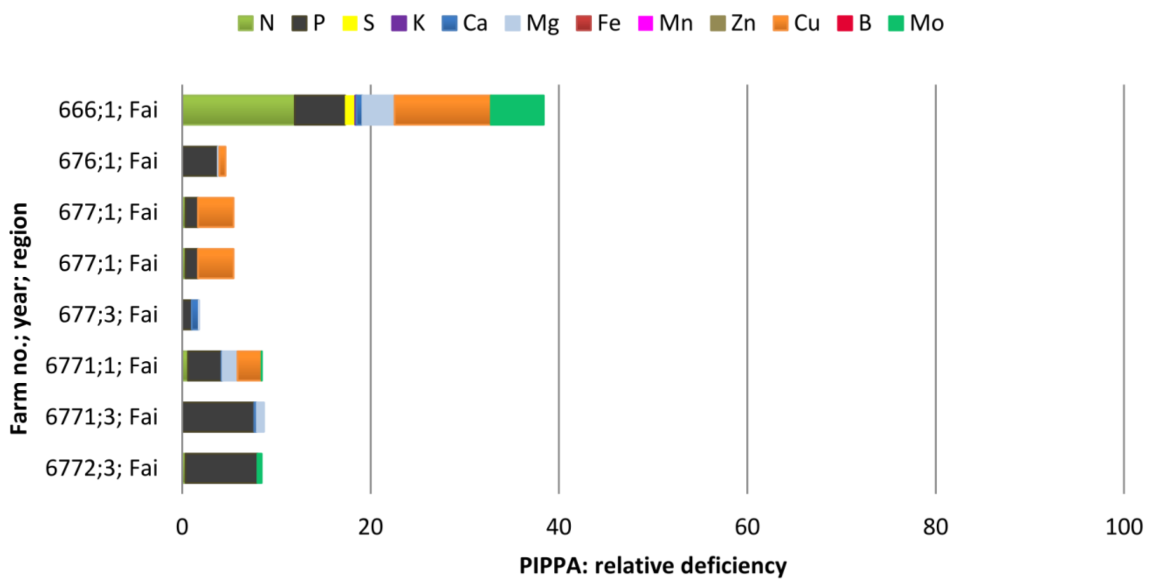


Fig. 4.12 continued

As explained in chapter 3.4.5, in addition to the actual approach of PIPPA, with which a diagnosis of nutrient deficiencies was carried out, excess plant tissue element concentrations with respect to the critical values determined by BOLIDES were also calculated. These values of surplus concentration in cotton tissue are listed in Tab. 8.26 in the Appendix. They are depicted as well as stapled bar charts with respect to each sampling site and year of sampling in Fig. 8.8 in the Appendix.

As shown for the deficient mineral concentrations in cotton leaf tissue analysed according to PIPPA, pronounced regional characteristics for the surplus mineral concentrations were visible, too:

- Generally, in all samples originating from the Beheira governorate (Beheira-W and Beheira-O), the degree of oversupply was moderate. Mo was predominantly detected in concentrations above the critical value determined according to BOLIDES. In many cases, Zn, Cu, Fe and Mn were identified exceeding the critical values, too. Among the macronutrients, Ca, and, to a minor extent Mg and S, showed a higher concentration than the corresponding critical values. Even the macronutrients K, P and in some cases N were present in more than sufficient concentrations in a few samples.
- At the Dakahlia, Damietta, Sharqia (W and O) and Qalyubia governorates, virtually all samples showed an over-supply with Fe. In a number of cases, other micronutrients like B, Cu, Zn, Mn and Mo showed excess supply, too. Among the macronutrients, P in many cases and occasionally N, S, Ca and Mg exceeded the corresponding critical values on a moderate level.
- Tissue samples from Faiyum showed a different pattern with pronounced excess concentrations for all micronutrients analysed: Mo, B, Cu, Zn and Mn. Among the secondary elements, S was often, and Ca and Mg in a number of cases detected in concentrations surpassing the corresponding critical values according to BOLIDES.

4.6.2 Evaluation according to DRIS-method

DRIS-indices for all 207 data sets were computed as explained in chapter 2.3.2 and 3.4.5. They are listed in Tab. 8.29 in the Appendix. Stapled bar charts indicating DRIS indices for each cotton leaf sample are compiled with Fig. 8.9 (Appendix):

- Concerning samples from the Beheira (W and O) governorate, the diagnosis according to DRIS revealed above all deficiencies for the micronutrients Fe, Mn, Zn, Cu and B and for the macronutrient P. In a number of plant tissue samples, S, N Ca and Mg were detected as being yield limiting, too. But there were also sites at Beheira where Mn, Cu, Zn, B and K were determined as exceeding plant needs. Mo, however, was diagnosed in most cases being in surplus, for many samples this was the case for S, Ca, Mg, Mn and Cu, too.
- At the Sharqia (W and O), Dakahlia, Damietta and Qalyubia governorates, most samples were diagnosed being deficient with respect to Mo, K, S and Ca. The majority of samples revealed concentrations of Fe, Mn, P and even N above plant needs. Cu and Zn were often in need, but in some tissue samples these elements were present in surplus.
- At Faiyum, DRIS indices revealed clear plant deficiencies for P, K, Cu, Zn, to a smaller extent for Ca and Mg and, in some samples for Mo. Excess supply was diagnosed for Fe, Mn, B and S and in some samples for Mo.

4.6.3 Evaluation according to CND-method

CND Indices I_N, I_P, I_K, ….. I_{Zn}, I_{Al}, I_{Rd} for all farms investigated were computed as explained in chapter 2.3.3 and 3.4.5 and are listed in Tab. 8.32 the Appendix. Stapled bar charts indicating indices for each cotton leaf sample can be seen under Fig. 8.10 (Appendix).

- Concerning Beheira (W and O) governorate, CND-evaluation did not result in a clear supply pattern. Elements which were in need in one analysed tissue sample show excess concentration in the other. In any case, S, Ca, Mg, Mo and Mn often were detected being in excess while P, K, Zn, and B were mostly analysed as being deficient.
- CND-indices of samples from the Dakahlia, Damietta, Qalyubia and Sharqia (W and O) governorates revealed a pronounced and common pattern: often, Mo, Zn, Cu, K, S and P were diagnosed as being deficient. Excess concentrations were detected for Fe and Mn. Nitrogen was detected deficient in some cases and in some cases in surplus.
- Tissue samples originating from Faiyum were often diagnosed deficient with respect to the plant nutrients P, K, N, Ca, Mg, Zn and Cu. Excess supply was determined with Fe, Mn and B.

On order to gain a better impression on how the different evaluation systems PIPPA, DRIS and CND assess the nutritional plant status, two approaches were chosen. Concerning the individual approach, the results of evaluations of nutrient deficiencies using PIPPA-, DRIS- and CND-method was carried out with respect to particular sampling sites at individual farms (chapter 0). Concerning the statistical approach, mean values of the different indices determined according to PIPPA, DRIS and CND were compared with respect to the year of sampling and the sampling region (chapter 0 and 4.6.6).

4.6.4 Exemplarily comparison of evaluations according to PIPPA, DRIS and CND for specific sampling sites

Typical sampling sites in each region (with the exception of Dakahlia/Damietta) were chosen to compare the results of the evaluation according to PIPPA, DRIS and CND. Tab. 4.13 lists features and chemical characteristics of the different fields sampled: according to soil analyses, the nutritious status shows more favorable conditions at Beheira-W (Farm no. 163) with respect to the supply of soils with the main nutrients N, P and K as well as with micronutrients, exemplarily listed are B and Mo. Nevertheless, relative yield at Sharqia-O (Farm no. 762) attained the same level under less favorable conditions. An important factor besides soil concentrations of plant available nutrients are the presence of competing elements (i. e. Na, and possibly Fe and Al) and nutrient fixing chemical compounds (i. e. carbonates, sulphates).

Nutrient deficiencies were evaluated according to PIPPA, DRIS and CND as listed in Tab. 4.14. Corresponding concentrations of soil (Tab. 8.13) and plant-tissue (Tab. 8.14) are listed in the Appendix.

- According to all three evaluation systems, Mn was the only element detected deficient at farm no. 163.
- At farm no. 710, deficiencies were only detected by DRIS and CND for P, Fe and Zn. No deficiencies were detected by use of PIPPA.
- Concerning farm no. 755 (Sharqia-W), PIPPA only evaluated a minor need for phosphorus, while DRIS and CND detected further deficiencies (K, Fe, Mn, Zn, Cu, Mo). The detected phosphorus-deficiency corresponds to a low P_{Olsen}-concentration in soil. The difference between the evaluation methods is at least partly due to higher critical values used by DRIS and CND in comparison with BOLIDES. Data on plant and soil analyses and the evaluation of deficiencies did not give sufficient reason for the lower relative yield of 65 %.
- PIPPA-evaluation for farm no. 757 (Sharqia-W) revealed a strong need for S (and a minor deficiency for K, Mn and B) whereas evaluation with DRIS and CND resulted in strong deficiency diagnoses concerning the elements S, K, and Zn. The absolute level of the critical value for S determined will be discussed in chapter 5. With respect to potassium and zink, the reason for the different evaluation are the higher critical values used by the systems DRIS and CND. Concerning Mn, the small gap between maximum and actual yield, which is assessed less severe by PIPPA due to the application of the boundary line, than by DRIS and CND, may be one reason for different evaluation results.
- Farm no. 762 (Sharqia-O) showed according to PIPPA, DRIS and CND stronger deficiencies concerning S, Ca, Zn and Mo, which corresponded to the related soil data.
- Deficiencies in leaf tissue of farm no. 677 (Faiyum) were diagnosed far more severe by DRIS and CND than by PIPPA.

Tab. 4.13: Characteristics of soil and crop from several Egyptian sites cultivated in 2010 with organically grown cotton (*Gossypium barbadense*).

Farm no.	Site	Certification	Production	Rel. Production	Variety	pH	C_{total}	C_{org}	$CaCO_3$	Ca_{LE}
			kg/ha	%			%	%	%	mg/kg
163	Beheira-W	demeter	3,750	108	GIZA 86	7.9	3.5	n.d.	n.d.	55,577
710	Beheira-O	organic	3,640	105	GIZA 86	7.9	2.0	1.0	7.7	17,179
755	Sharqia-W	organic	2,250	65	GIZA 86	7.8	1.8	0.9	7.5	20,142
757	Sharqia-W	organic	3,125	90	GIZA 86	7.9	1.8	0.6	9.6	23,116
762	Sharqia-O	organic	3,750	108	GIZA 86	8.0	0.9	0.2	5.4	10,169
7822	Dakahl.-Da	demeter	3,000	87	GIZA 85	8.1	1.7	1.1	5.3	14,611
696	Qalyubia	demeter	3,375	97	GIZA 86	8.0	1.6	0.9	5.5	13,711
677	Faiyum	demeter	3,000	87	GIZA 90	8.2	1.7	0.7	8.8	28,169

Farm no.	N_{total}	K_{CAL}	P_{Olsen}	S_{LE}	Fe_{LE}	Al_{LE}	B_{LE}	Mo_{LE}	Na_{H2O}	El. conductivity
	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µS/cm
163	0.15	726	41.5	1,217	1	41.8	10.7	0.027	2,617	1,864
710	0.09	294	21.5	277	118	146	2.47	0.007	518	419
755	0.07	285	15.9	761	207	177	3.12	0.008	2,619	1,804
757	0.04	313	30.7	504	200	175	3.62	0.008	1,629	1,000
762	0.02	88	20.0	20	147	182	2.91	0.003	1,470	858
7822	0.08	259	21.0	512	281	194	4.06	0.004	1,622	943
696	0.08	573	25.4	159	93	104	2.37	0.007	251	281
677	0.05	352	7.5	145	120	172	3.36	0.009	588	309

Tab. 4.14: Nutrient deficiencies of organically grown Egyptian cotton (*Gossypium barbadense*) sampled at eight different farms in July 2010 according to PIPPA, DRIS and CND.

PIPPA												
Sampling sites (regions)	**N**	**P**	**S**	**K**	**Ca**	**Mg**	**Fe**	**Mn**	**Zn**	**Cu**	**B**	**Mo**
163 (Beheira-W)	0	0	0	0	0	2	0	10	0	0	0	0
710 (Beheira-O)	0	0	0	0	0	0	0	0	0	0	0	0
755 (Sharqia-W)	0	1	0	0	0	0	0	0	0	0	0	0
757 (Sharqia-W)	0	0	14	2	0	0	0	2	0	0	1	0
762 (Sharqia-O)	0	0	15	0	4	0	0	0	15	0	0	7
7822 (Dakahlia-Da.)	25	0	5	23	5	9	0	19	0	0	7	12
696 (Qalyubia)	1	0	8	20	4	19	0	1	0	0	1	6
677 (Faiyum)	0	2	0	0	1	0	0	0	0	0	0	0
DRIS												
Sampling sites (regions)	**N**	**P**	**S**	**K**	**Ca**	**Mg**	**Fe**	**Mn**	**Zn**	**Cu**	**B**	**Mo**
163 (Beheira-W)	0	0	1	1	3	5	5	31	0	4	4	0
710 (Beheira-O)	0	9	1	0	0	0	31	0	8	1	3	0
755 (Sharqia-W)	0	17	0	14	0	0	3	15	18	3	0	10
757 (Sharqia-W)	0	1	19	11	0	0	0	14	10	0	3	3
762 (Sharqia-O)	0	0	15	0	6	0	0	0	26	3	0	25
7822 (Dakahlia-Da.)	6	0	0	26	0	0	0	29	0	0	0	29
696 (Qalyubia)	0	0	6	28	4	12	0	5	0	0	0	22
677 (Faiyum)	3	19	1	12	12	6	0	0	13	7	0	0
CND												
Sampling sites (regions)	**N**	**P**	**S**	**K**	**Ca**	**Mg**	**Fe**	**Mn**	**Zn**	**Cu**	**B**	**Mo**
163 (Beheira-W)	0.0	0.0	0.2	0.1	0.2	0.5	0.0	1.6	0.0	0.3	0.3	0.0
710 (Beheira-O)	0.0	0.5	0.1	0.0	0.0	0.0	0.6	0.0	0.5	0.0	0.2	0.0
755 (Sharqia-W)	0.1	1.1	0.0	1.2	0.0	0.0	0.0	0.8	1.3	0.3	0.0	0.4
757 (Sharqia-W)	0.0	0.4	3.7	1.4	0.2	0.0	0.0	1.1	1.1	0.2	0.6	0.3
762 (Sharqia-O)	0.0	0.0	3.0	0.4	0.7	0.0	0.0	0.0	2.0	0.5	0.0	1.2
7822 (Dakahlia-Da.)	0.9	0.0	0.5	2.4	0.2	0.4	0.0	1.8	0.2	0.0	0.2	1.3
696 (Qalyubia)	0.0	0.0	1.5	2.8	0.2	0.0	0.0	0.9	0.0	0.0	0.0	1.9
677 (Faiyum)	1.0	1.6	1.1	1.5	1.3	1.2	0.0	0.0	1.4	1.0	0.0	0.0

- At Dakahlia/Damietta, plant tissue from farm no. 7822 revealed with all three systems a need for N, K, Mn and Mo, according to PIPPA and DRIS also minor deficiencies for further nutrients.
- At Qalyubia, PIPPA evaluated tissue from farm no. 696 deficient for a range of elements: S, K, Mg and Mo.

The matrix of Tab. 4.15 summarizes the diagnosis of the three evaluation systems with respect to the eight sampling sites at different farms. Deficiencies indicated are most numerous using CND, followed by DRIS and PIPPA. Generally, the matrix visualizes a good consistency of the results of the three evaluation systems.

Tab. 4.15: Comparison of diagnoses according to PIPPA, DRIS and CND for deficiencies of organically grown Egyptian cotton (*Gossypium barbadense*) sampled at eight different farms in July 2010.

Farm no.	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo
163			blue	blue, orange	blue, orange, green	blue, orange, green	blue, orange	blue, orange, green		blue, orange	blue, orange	
710		blue, orange, green	blue, orange				blue, orange		blue, orange	orange	blue, orange	
755		blue, orange, green		blue, orange			orange	blue, orange	blue, orange	blue, orange		blue, orange
757		blue	blue, orange, green	blue, orange, green	blue			blue, orange, green	blue, orange	blue	blue, orange, green	blue, orange
762			blue, orange, green	blue	blue, orange, green				blue, orange, green	blue, orange		blue, orange, green
7822	blue, orange, green		blue, green	blue, orange, green	blue, green	blue, green		blue, orange, green	blue		blue, green	blue, orange, green
696	green		blue, orange, green	blue, orange, green	blue, orange, green	orange, green		blue, orange, green			green	blue, orange, green
677	blue, green		blue	blue, orange	blue, orange, green	blue, orange			blue, orange	blue, orange		

CND: blue, DRIS: orange, PIPPA: green

4.6.5 Variation of indices in different years

Tab. 4.16 gives an overview over the deficiencies which were diagnosed by the different evaluation systems PIPPA, DRIS and CND with respect to the year of sampling (see also Tab. 8.24, 8.30 and 8.33, Appendix). As these are mean values and PIPPA indicated a smaller number of deficiencies, values for PIPPA are less elevated than for DRIS.

More obvious than strong yearly variations within the single evaluation system are the differences between the evaluation systems. Over all years, all systems count P, K and Mo and P among the most needed elements. N and S deficiencies were estimated as being more serious by PIPPA and CDN than by DRIS. Fe, Mn, Zn, and Cu deficiencies were diagnosed as more serious by DRIS and CND than by PIPPA.

In Tab 4.17, the excess supply with plant nutrients, calculated on the basis of the critical values determined by BOLIDES and diagnosed by the evaluation systems DRIS and CND are listed (see also Tab. 8.27, 8.30 and 8.33, Appendix). Excess values with reference to BOLIDES are determined by subtracting the critical value from the actual plant tissue concentration and therefore are in absolute values more elevated than the indices used by the evaluation systems DRIS and CND.

All three evaluations reveal – on the average – an over-supply with the micronutrients Fe and Mo. Excess supply of Zn was detected being more severe by DRIS than by the other two systems. Mn and B were identified as being in excess by CND with the highest level, while for the other two systems, the over-supply was less severe. Generally, there were fewer indications for the plant tissue concentrations of the macronutrients N, P, K, S, Ca, Mg than for the micronutrients to be in excess. This difference between macro- and micronutrients was estimated larger by the univariate approach using BOLIDES critical values and by DRIS and smaller by the CND-evaluation system.

Tab. 4.16: Nutrient deficiencies of organically grown Egyptian cotton (*Gossypium barbadense*) in the years 2008-2010 according to PIPPA, DRIS and CND.

PIPPA												
Year	**N**	**P**	**S**	**K**	**Ca**	**Mg**	**Fe**	**Mn**	**Zn**	**Cu**	**Bo**	**Mo**
2008	2.1	3.1	3.1	2.6	2.4	2.5	2.4	1.6	0.3	4.1	3.0	3.8
2009	3.8	2.4	3.0	3.7	2.6	1.9	1.4	0.0	0.4	0.2	2.4	4.9
2010	2.5	1.5	2.4	4.7	1.1	1.5	0.0	1.4	0.4	0.1	0.8	1.9
Total	2.8	2.4	2.9	3.6	2.0	2.0	1.2	0.7	0.4	1.6	2.1	3.6
DRIS												
Year	**N**	**P**	**S**	**K**	**Ca**	**Mg**	**Fe**	**Mn**	**Zn**	**Cu**	**B**	**Mo**
2008	2	9	3	7	3	3	11	7	4	9	3	15
2009	4	10	3	10	4	3	9	2	8	2	3	16
2010	2	9	4	12	3	2	10	5	8	3	1	7
Total	3	9	3	10	3	3	10	5	7	5	2	13
CND												
Year	**N**	**P**	**S**	**K**	**Ca**	**Mg**	**Fe**	**Mg**	**Zn**	**Cu**	**B**	**Mo**
2008	0.37	0.62	0.72	0.78	0.26	0.41	0.18	0.35	0.40	0.81	0.26	0.59
2009	0.56	0.67	0.93	1.03	0.43	0.45	0.19	0.14	0.77	0.29	0.32	0.70
2010	0.30	0.64	0.97	1.08	0.23	0.25	0.19	0.28	0.69	0.31	0.17	0.34
Total	0.41	0.64	0.87	0.96	0.31	0.37	0.19	0.26	0.61	0.48	0.25	0.55

Tab. 4.17: Excess nutrient supply of organically grown Egyptian cotton (*Gossypium barbadense*) in the years 2008-2010 calculated on the basis of critical values determined by BOLIDES and calculated by DRIS and CND.

Relative to critical values determined by BOLIDES												
Year	**N**	**P**	**S**	**K**	**Ca**	**Mg**	**Fe**	**Mn**	**Zn**	**Cu**	**B**	**Mo**
2008	4	12	7	8	6	5	52	22	24	4	18	14
2009	2	6	8	8	10	2	107	14	11	20	17	34
2010	8	5	5	11	9	14	51	28	20	16	16	47
Total	5	8	7	9	9	7	70	22	18	13	17	31
DRIS												
Year	**N**	**P**	**S**	**K**	**Ca**	**Mg**	**Fe**	**Mn**	**Zn**	**Cu**	**Bo**	**Mo**
2008	1.9	8.9	3.0	7.3	3.3	3.1	10.7	6.9	4.1	9.0	2.5	14.9
2009	3.7	9.7	3.4	9.8	4.0	3.0	9.4	2.0	8.3	1.7	2.7	16.0
2010	2.0	9.2	4.1	11.7	2.5	1.7	10.1	4.6	8.2	2.8	1.5	7.3
Total	2.5	9.2	3.5	9.5	3.3	2.6	10.1	4.6	6.8	4.6	2.3	12.9
CND												
Year	**N**	**P**	**S**	**K**	**Ca**	**Mg**	**Fe**	**Mn**	**Zn**	**Cu**	**B**	**Mo**
2008	0.43	0.41	0.27	0.19	0.27	0.33	0.53	0.54	0.35	0.06	0.60	0.16
2009	0.10	0.12	0.30	0.08	0.37	0.09	0.92	0.31	0.05	0.32	0.41	0.44
2010	0.28	0.10	0.11	0.09	0.28	0.42	0.49	0.68	0.16	0.12	0.39	0.55
Total	0.28	0.22	0.23	0.12	0.31	0.28	0.64	0.51	0.19	0.17	0.47	0.38

4.6.6 Geographical variation of indices

Tab. 4.18 shows the results of the evaluation by PIPPA, DRIS and CND with respect to the sampling region. As these are mean values and PIPPA indicated a smaller number of deficiencies, values for PIPPA are less elevated than for DRIS (see also Tab. 8.25, 8.31 and 8.34, Appendix).

Tab. 4.19 summarizes the results of the evaluation of nutrients deficiencies in cotton leaf tissues with respect to the different sampling sites, and thus gives an interpretation of Tab. 4.18. This matrix visualizes that diagnosis conducted by means of the different systems PIPPA, DRIS and CND (deficiencies increase in the direction “light →dark colouring”):

- At Beheira (W and O), moderate deficiencies were diagnosed for Mn, Cu, B and Mo. Stronger Fe deficiencies were diagnosed in this region, a result that will be further discussed in chapter 5.
- Samples from the Sharqia-W region were diagnosed bearing strong deficiencies for S, K and Mo and moderate needs for Ca, Cu and B. Samples from Sharqia-O showed grave deficiencies for S, K, Zn and Mo, furthermore minor needs for N, P, Ca, Cu and B.
- The governorates Dakahlia and Damietta showed strong needs for N, S, K, Mn and Mo, and a minor deficiency for the minerals Ca and Mg.
- Qalyubia was diagnosed severely deficiencient concerning the minerals P, K and Mo, and deficient on a lower level concerning S, Mg and Mn.
- Cotton plants at Faiyum revealed strong needs for P and Cu and less severe deficiencies for K, Ca, Mg and Mo.

In chapter 5, results will be discussed further in relation to other factors influencing yield performance.

Tab. 4.18: Nutrient deficiencies of organically grown Egyptian cotton (*Gossypium barbadense*) in the different sampling regions according to PIPPA, DRIS and CND.

PIPPA												
Region	**N**	**P**	**S**	**K**	**Ca**	**Mg**	**Fe**	**Mn**	**Zn**	**Cu**	**B**	**Mo**
Beheira-W	0.9	1.0	0.3	0.3	0.2	1.5	1.6	0.0	0.2	1.0	2.1	0.4
Beheira-O	2.0	1.3	1.0	0.2	2.4	1.5	3.3	1.2	0.3	0.9	2.4	2.1
Sharqia-W	3.0	0.3	7.0	5.9	3.4	1.5	0.0	1.4	0.0	1.2	2.8	5.9
Sharqia-O	3.7	1.3	6.6	7.5	3.4	2.1	0.2	0.0	1.9	2.9	3.0	8.0
Dakahlia-Da.	15.9	0.0	4.2	9.5	2.6	4.1	1.9	11.5	0.0	0.9	3.2	8.2
Qalyubia	1.9	4.3	4.2	12.3	1.2	3.1	0.0	1.1	0.0	0.0	0.5	5.8
Faiyum	2.3	9.8	0.4	2.1	1.2	3.0	0.0	0.0	0.0	3.3	0.0	0.7
Total	2.8	2.4	2.9	3.6	2.0	2.0	1.2	0.7	0.4	1.6	2.1	3.6
DRIS												
Region	**N**	**P**	**S**	**K**	**Ca**	**Mg**	**Fe**	**Mn**	**Zn**	**Cu**	**B**	**Mo**
Beheira-W	2.0	5.5	1.1	4.0	0.7	2.8	17.7	4.2	6.1	4.9	4.4	3.0
Beheira-O	2.9	8.6	2.1	2.7	4.1	2.5	19.3	6.7	7.6	2.8	3.3	7.0
Sharqia-W	0.8	2.4	8.0	15.8	4.6	0.7	7.1	6.9	4.3	3.4	1.3	18.6
Sharqia-O	2.0	3.3	7.1	15.2	4.8	1.1	2.1	0.0	8.7	4.8	2.0	26.5
Dakahlia-Da.	7.9	0.0	2.7	18.3	2.2	3.8	4.3	21.7	0.2	1.5	0.3	29.5
Qalyubia	1.1	11.1	4.3	23.6	0.8	2.3	0.2	2.5	2.1	0.9	0.0	22.6
Faiyum	3.9	32.6	0.5	8.5	3.9	6.4	0.0	0.4	10.6	11.9	0.0	6.4
Total	2.5	9.2	3.5	9.5	3.3	2.6	10.1	4.6	6.8	4.6	2.3	12.9
CND												
Region	**N**	**P**	**S**	**K**	**Ca**	**Mg**	**Fe**	**Mn**	**Zn**	**Cu**	**B**	**Mo**
Beheira-W	0.17	0.36	0.26	0.38	0.05	0.22	0.32	0.19	0.44	0.41	0.35	0.12
Beheira-O	0.33	0.61	0.44	0.31	0.24	0.29	0.38	0.34	0.57	0.24	0.29	0.24
Sharqia-W	0.25	0.20	1.70	1.49	0.47	0.19	0.12	0.47	0.43	0.38	0.29	0.82
Sharqia-O	0.40	0.31	1.71	1.52	0.50	0.28	0.03	0.02	0.87	0.59	0.37	1.13
Dakahlia-Dam.	1.10	0.04	0.89	1.74	0.33	0.63	0.08	1.24	0.26	0.33	0.16	1.29
Qalyubia	0.33	0.88	1.31	2.14	0.16	0.35	0.00	0.20	0.31	0.19	0.01	1.01
Faiyum	0.96	2.09	0.51	1.08	0.49	1.01	0.00	0.04	1.07	1.24	0.00	0.36
Total	0.41	0.64	0.87	0.96	0.31	0.37	0.19	0.26	0.61	0.48	0.25	0.55

Tab. 4.19: Deficiencies diagnosed by the evaluation systems PIPPA, DRIS and CND in young, fully matured, main stem leaves of organically grown Egyptian cotton (*Gossypium barbadense*), mean values from seven different sampling regions over three years (2008-2010).

Region	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo
Beheira-W												
Beheira-O												
Sharqia-W												
Sharqia-O												
Dakah.-Da.												
Qalyubia												
Faiyum												

CND: blue, DRIS: orange, PIPPA: green

Tab. 4.20: Excess supply of organically grown Egyptian cotton (*Gossypium barbadense*) in different sampling regions calculated on the basis of critical values determined by BOLIDES and determined by DRIS and CND.

Relative to critical values determined by BOLIDES												
Region	**N**	**P**	**S**	**K**	**Ca**	**Mg**	**Fe**	**Mn**	**Zn**	**Cu**	**B**	**Mo**
Beheira-W	7	7	9	10	12	8	15	17	20	19	7	42
Beheira-O	5	8	6	20	12	10	39	14	18	16	11	61
Sharqia-W	9	12	3	1	8	12	90	5	24	10	12	10
Sharqia-O	3	10	1	2	4	2	115	19	8	7	5	3
Dakahlia-Da.	2	20	4	1	1	0	136	10	15	9	9	0
Qalyubila	2	4	1	0	4	5	74	16	25	17	18	3
Faiyum	2	0	18	9	7	3	117	71	22	7	66	33
Total	5	8	7	9	9	7	70	22	18	13	17	31
DRIS												
Region	**N**	**P**	**S**	**K**	**Ca**	**Mg**	**Fe**	**Mn**	**Zn**	**Cu**	**B**	**Mo**
Beheira-W	2	2	3	1	6	3	1	7	2	4	2	9
Beheira-O	2	5	2	4	5	5	9	5	3	2	4	16
Sharqia-W	6	7	0	0	3	7	29	1	5	2	5	1
Sharqia-O	5	7	1	0	3	4	40	13	2	3	4	1
Dakahlia-Da.	4	14	4	1	1	1	45	4	2	2	4	0
Qalyubia	3	3	1	0	4	5	21	10	7	7	10	1
Faiyum	1	0	6	0	3	1	30	31	4	1	26	7
Total	3	4	2	1	4	4	20	10	3	3	7	7
CND												
Region	**N**	**P**	**S**	**K**	**Ca**	**Mg**	**Fe**	**Mn**	**Zn**	**Cu**	**B**	**Mo**
Beheira-W	0.35	0.13	0.51	0.10	0.53	0.27	0.12	0.49	0.19	0.39	0.20	0.56
Beheira-O	0.28	0.30	0.22	0.36	0.41	0.41	0.35	0.37	0.23	0.17	0.31	0.80
Sharqia-W	0.46	0.30	0.06	0.00	0.30	0.50	0.80	0.06	0.26	0.04	0.42	0.08
Sharqia-O	0.28	0.25	0.08	0.01	0.15	0.19	1.04	0.61	0.07	0.09	0.19	0.03
Dakahlia-Dam.	0.37	0.60	0.24	0.08	0.06	0.07	1.35	0.13	0.10	0.06	0.17	0.03
Qalyubia	0.15	0.10	0.04	0.00	0.18	0.18	0.86	0.44	0.30	0.28	0.61	0.03
Faiyum	0.00	0.00	0.29	0.00	0.12	0.03	1.05	1.33	0.18	0.01	1.68	0.25
Total	0.28	0.22	0.23	0.12	0.31	0.28	0.64	0.51	0.19	0.17	0.47	0.38

In Tab. 4.20, excess supply in relation to critical values determined by BOLIDES and determined by the evaluation systems DRIS and CND are listed with respect to the different sampling regions of the present study (see also Tab. 8.28, 8.31 and 8.34, Appendix). Many of the elements exceeding demand as diagnosed by comparing leaf tissue concentrations with BOLIDES values were micronutrient: a large quantity of plant tissue evaluations revealed an over-supply with Fe, Mn, Zn, Cu, B and Mo. This was the case for DRIS- and for CND diagnosis systems, too (the latter with less pronounced differences between macro- and micronutrient-surplus values).

- Cotton leaf tissue samples from the Beheira governorate showed excess supply especially for Mo and a good provision with macro- and micronutrients.
- Fe, Mn and B were diagnosed being present in excess at Sharqia, Damietta, Qalyubia and Faiyum.
- At Faiyum, Mn, B and, to a lower extent Mo, were diagnosed being in surplus by all evaluation system.

In chapter 5, these results and their interdependencies with other findings will be discussed further.

5 Discussion

There is a world-wide increasing demand for organic cotton. In Egypt, long-staple, high quality cotton of the variety *Gossypium barbadense* is traditionally cultivated by farmers on alluvial soils of the Nile valley and the delta.A growing number of farmers produce organic cotton. Due to the construction of the Assuan High Dam, regular annual floodings, which furnished the fields with nutritious elements and washed out excess salts, seized four decades ago. Whereas there are numerous information on the fertilization of the worldwide most cultivated variety *Gossypium hirsutum,* information on the fertilization of *Gossypium barbadense* is limited. No specific target values, so-called critical values, are available for soil and plant parameters as a guideline for fertilization. Objectives of the present study therefore are to

- collect data on the mineral composition of *Gossypium barbadense* cultivars grown in Egypt at a defined growth stadium, on the nutrient status of the corresponding cotton grown soils, and on the yields attained applying fertilizers, soil conditioners and plant strengtheners according to organic respectively biodynamic cultivation standards,
- apply statistical methods to derive an assessment scheme and to evaluate this assessment scheme,
- provide information for optimization of the nutrition of the cotton crop by means of fertilization and others in accordance with the standards of organic farming.

Modifying the above order, first the methodical aspects of this thesis will be discussed, followed by a discussion of the analytical data.

- The Boundary Line Developement System (BOLIDES), a method for the deduction of critical values, respectively curves or equations which were for this thesis programmed in Mathematica 7, will in a first step be examined and compared to other methods for the deduction of critical values (Beaufils, 1973; Cate and Nelson, 1971; Khiari, et al., 2001a). The actual values obtained by BOLIDES and other methods will be compared.
- Secondly, PIPPA as the evaluation method for individual data used in connection with BOLIDES (Schnug, 1990), will be compared to the alternative methods DRIS (Beaufils, 1973; Beaufils et al., 1976; Walworth and Sumner, 1987) and CND (Parent and Dafir, 1992). Results of the present evaluation with respect to the data set will be commented.
- Thirdly, the deduced critical values will be compared with data from literature and their reliability will be discussed.
- Fourthly, results of the evaluation of plant analysis data using the assessment scheme are inspected and set into relation to soil analysis data and further information gathered.
- Fifthly, measures for the optimization of the nutrition of the cotton crop will be deduced.
- Last and least, further research needs in connection with the present investigation will be summarized.

5.1 Methodical approach for assessing critical values

A fundamental difference between the approach of the BOLIDES method and other methods for the determination of critical values is, that with BOLIDES a curve and the corresponding function is determined, which relates a range of element concentrations in plants as independing variables to maximum yields as depending variables, with reference to the specific element concentration. Maximum value of the curve is the actual critical value. Other methods do not apply this continuous relation between independing and depending variable, i. e. between plant nutrient concentration and yield. All other methods choose mean values of a superior subgroup as critical value. Different approaches were exercised by Beaufils (1973), Cate and Nelson (1971) and Khiari et al. (2001a) to cut off the data of the group performing high yields from the rest of the data set, i. e. to determine the group size of the best performers.

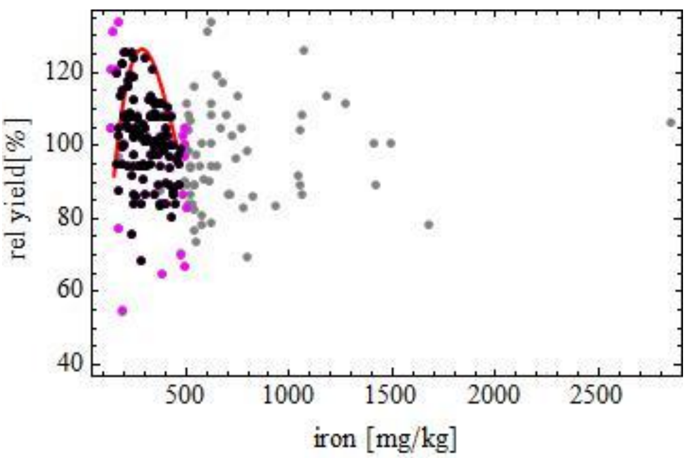
Below, the programming of BOLIDES according to those principles first published by Heym and Schnug (1995) and its application on a given data set is discussed, followed by the DRIS-approach developed by Beaufils and Sumner (1976) and Walworth and Sumner (1987) and the CND-approach as proposed by Parent and Dafir (1992).

5.1.1 Boundary Line Developement System (BOLIDES)

The boundary line method takes into account the multidependence of yield performance from a number of factors. Only the best performing plots or fields determine the shape of the boundary line. There is no statistical method to deduce the boundary line from a given data set, but Heym and Schnug (1995) respectively Schnug et al. (1995) proposed a methodical approach for its construction. One aim of the present study was programming this approach and testing the program using a given data set. There were a number of points which were considered during the process of programming and testing:

Outlier reduction

Schnug et al. (1995) defined a “rectangle criterium” and a “circular criterium” to identify and eliminate outliers from the data set. Instead of transforming these criteria into Mathematica-expressions, “nearest neighbour areas”, based on the Frobenius norm (Weisstein, 2011), were constructed. For this approach it is assumed that the mean values of the x- and y-coordinates are situated in the bulk of the data and that only a few data points are to be eliminated as outliers.



boundary line=red, manually eliminated outliers=gray points, data eliminated by use of the Frobenius norm=magenta points, data relevant for the boundary line construction=black points

Fig. 5.1: Scatter diagram for plant tissue samples of *Gossypium barbadense* with respect to the plant nutrient Fe with deduced boundary line, data points manually eliminated, eliminated by use of the Frobenius norm and remaining data points.

During the calculation process, the procedure for eliminating outliers can be adapted by changing the number of outliers to be removed. This option was chosen in the case of the determination of the critical value for potassium.

In some cases, however, when outliers were dispersed asymmetrically, the above elimination procedure was not sufficient. This was the case concerning the analysis data of B and Fe. The distribution of these two elements showed positive skewness with a large proportion of outliers, probably due to contamination. Workaround was managed by eliminating a large proportion of values before getting into the procedure (Fig. 5.1).

Construction of the step function

Programming the construction of the step function was chosen on the basis of the proposition of Schnug et al. (1995). Several difficulties were encountered:

The fitting of the boundary line to the upper step function alone was not satisfying. This was the case especially for the distributions of data on micronutrient concentration in plant tissue. In many cases, scatter plots showed an accumulation of data points at their very left side. As a consequence, the number of points which could be constructed alone by the use of the upper step function was not sufficient for the tight fit of a boundary line. This problem was the reason why during the process of programming, step functions on the left and right side of the bulk of the data points were added. It is a matter of discussion, whether the right-side step function is necessary for the construction of a boundary line, the left-side step function turned out to be essential for the construction of boundary lines around scatter plots of micronutrients. One disadvantage of the use of left- and right-side step function is that the fitted boundary line tends to “sink” into the scatter plot.

The length of the steps of the left-, upper- and right-side step function determines, how far the single step will “sink” into the scatter diagram. In consequence, either the single step consists of more points and is situated further at the edge of the scatter plot or the single step is composed of fewer points and follows more the changing shape of the scatter plot. As the fitted boundary line will follow all step function lines, a compromise has to be met concerning the length of the steps (Fig. 3.16).

The above consideration will be less important, the more data are available, as the majority of data will accumulate further in the center of the scatter diagram and even more outliers can be removed in order to obtain a distinct boundary line.

Fitting of the boundary line

The fitting of the boundary lines was tested visually with polynomial of the 2nd, 3rd and 4th order. The quality of the fitting was generally better with macronutrients than with micronutrients. The best fitting curves were of 2nd and 3rd order, as the 4th-order curves tend to flutter. No statistical test was applied to test the quality of fitting of the different polynomials to the step functions.

Concerning the micronutrients, the quality of fitting was less satisfying, as, even after outliers were eliminated, all polynomials tend to leave aside the upper left points of the scatter plot, what signifies, that critical values determined for these elements are slightly too high. As alternative, a Mitscherlich boule was constructed in pre-tests, particularly for the micronutrients, using only left and upper boundary steps in order to outline more precisely the top left edge of the plots. This approach was neglected as no distinct extrema and therefore no distinct coordinates of a critical value can be determined using the Mitscherlich function.

Definition of critical values, sufficiency ranges and validity range

The definition of critical values (maximum of the polynomial) and sufficiency ranges (95 % of the maximum) was taken over as explained by Heym and Schnug (1995). Not considered was a possible toxic effect of nutrients at high concentrations. As in organic agriculture only slow release mineral fertilizers are accepted under certain circumstances, there was no reason to expect that macronutrients were available in excess amounts. Concerning micronutrients, the problem arose regarding the distinction between superficial contamination of the leaves and excess supply (see Tab. 3.3). It is therefore consistent to define the validity range as range between lowest nutrient level not excluded as outlier and upper end of the sufficiency range.

Variation of critical values according to the year of sampling

Two-way ANOVA showed, that the year of sampling had an influence on nutrient concentration in leaf tissue and, in consequence, on the critical values (Tab. 4.4 and Fig 8.7, Appendix). The influence of the year of sampling on the position of BOLIDES and the critical value as maximum point was quite strong for some of the nutrients (i. e. Cu and Mo) but not as pronounced for others (i. e. N, P, S, K). Variations are most probably due to varying climatic conditions over the years and/or water shortages.

Regional boundary lines and critical values

Boundary lines specifically for a region were established and critical values derived for the two governorates Beheira (high yielding) and Sharqia (low yielding) (Fig. 8.6, Appendix). Higher critical values were determined for Beheira governorate for S, K, Ca, Cu and Mo, indicating a higher supply at the high yielding region in comparison to the low yielding region. Especially Fe – and to a small extent P – showed a lower critical value at the high yielding region Beheira than at Sharqia as region exhibiting a lower potential yield. Equal critical values for both sampling sites were deduced for N, Mg and Mn. critical values for Zn and B were only slightly lower at Sharqia than at Beheira. The above described differences between the regional critical values of Beheira and Sharqia governorate clearly mirrors in the distribution of the actual mineral concentrations in cotton leaf tissues sampled in the two governorates (Fig. 8.3, Appendix).

The question arises whether regional critical values are justified in order to predict local fertilization recommendations. The present example illustrates, that local critical values very clearly show the difference in potential yields between sites. As regards the low yielding regions, they indicate the restrictions for obtaining a higher yield. These restrictions may be a shortage of nutrients, a surplus of nutrients, or there even may be another reason like salinity and/or water stress for not reaching high yields. Others than nutrient-related growth factors may be concluded from the results of the correlation analysis (Tab. 4.5 to Tab. 4.8).

Therefore, it can be concluded from the present example of the interpretation of plant tissue analysis data, that the establishment of local critical values can be helpful for the determination of local potential yields. To similar conclusions came Dagbenonbakin (2005) in Benin: in order to carry out an evaluation with DRIS, he had distinguished two sub-populations of cotton according to yield achievements in order to use tissue concentrations of the higher yielding subpopulation as target values. He then compared the nutrient-concentrations of both sub-groups with critical values established in America (Sabbe and Mackenzie, 1973) and came to the result that both, high-yielding and low yielding sub-population in Benin posessed much lower nutrient concentrations. Dagbenonbakin (2005) concluded that the established target values from the high yielding population were deduced under suboptimal conditions and that they therefore represented rather local site effects than the potential of the variety. As local effects are far more predominant with respect to soil analysis, critical values for soil evaluation should, according to Evanylo and Sumner (1987), rather be deduced specifically to certain regions and/or soils.

The establishment of regional (or variety specific) critical values can therefore give fundamental information on the particular conditions of the crop growth. Comparing tissue nutrient concentrations with critical values established under different conditions and for other varieties can lead to misinterpretation, overestimation of the local potential yield and to oversized fertilizer recommendations.

5.1.2 Calculating critical values from a high yielding subpopulation

Different approaches for the separation of a high yielding subpopulation from the total population in order to calculate critical values were tested. The method used in connection with DRIS by Beaufils and Sumner (1976) was to simply choose the best 15 or 20 % of a population and calculate mean values of the plant tissue analysis data. More complicated iteration procedures to cut off the high yielding subpopulation were proposed by Cate and Nelson (1971) and by Khiari et al. (2001a), the latter in connection with the CND-method.

The Cate and Nelson (1971) procedure employs a coefficient of determination (R^2), which is successively calculated for different subgroups and is usually employed for soil and plant tests with increasing input of fertilizers and defined substrates or soils. In these cases, a distinct correlation between the independent factor (nutrient) and the dependent factor (yield) can be observed and growth curves like the Mitscherlich boule can be deduces from the data (i. e. Ohki, 1974, 1975 and 1976). The lower left quadrant of the corresponding scatter plot of the data shows the concentrations which are not sufficient to obtain optimal growth and the upper left quadrant shows optimum yield and - towards the right side of the plot - increasing luxury consumption. The critical value devides these two groups, which is visually quite obvious and can be detected by the highest R^2-value when applying the procedure proposed by Cate and Nelson (1971).

The example in Tab. 8.21 (Appendix), in which the successive R^2-values for P-concentrations in leaf blades were calculated clearly visualizes, that R^2-values for the postulated critical value at each division of the two subgroups do not gradually increase with rising nutrient level up to a cut off point and do not gradually fall towards further rising plant-levels either. Instead, R^2-values fluctuate and do not allow the determination of a distinct cut-off point.

The reason for the failure of the method lies in the character of the present investigation, which is about a field survey and not a fertilizer response experiment under defined conditions. Not only the nutrient in focus influences the yield level but also other nutrients or even unknown factors. The nutrient concentrations themselves do not necessarily reach neither extreme low values, which would correspond to the lower left quadrant of the plot, nor extreme high values, which would correspond to the higher right quadrant of the scatter plot. Therefore the plant nutrient / yield relation does not follow a curve but a scattered cloud and a division of data according to Cate and Nelson (1971) is not possible either graphically or by calculations.

The iteration process using the cumulative variance ratio as proposed by Khiari et al. (2001a) could be performed with the data set of the present survey: Tab. 8.22 (Appendix) lists cumulative variance ratios for all analyzed leaf tissue elements. As proposed by the authors, the ratios were transferred into a graph and a cumulative variance function as polynomial of 3rd degree was fitted. The result obtained by this procedure was not satisfactory as different inflection points of the constructed cumulative variance ratio functions for the different plant nutrients would lead to a range of cut-off points (Fig. 8.4, Appendix). The reason why this procedere failed is in this case the same as for the statistical method proposed by Cate and Nelson (1971). As the data were obtained from on-farm investigations, the relation between yield and tissue nutrient concentration is varying over a large scale because the yield performace of the crop is a multidepending issue.

5.1.3 Comparison of the results obtained by the different methods

Critical values for organic Egytian cotton (*Gossypium barbadense*) were determined according to BOLIDES and DRIS as shown in Tab. 5.1. Reference data for critical values for *Gossypium hirsutum,* which are deduced from a compilation in the Appendix (Tab. 8.3 and 8.4), are added.

In comparison to the critical values determined by DRIS, the procedure according to BOLIDES produces a higher value for N, comparable values for Ca and Mg and lower values for P, S, K, Fe, Mn, Zn, Cu, B and Mo.

The critical values which were obtained by DRIS are in many cases higher than the ones determined by BOLIDES. This is due to the standard procedure applied with BOLIDES to eliminate outliers – best performing ones as well – and construct a line outside the remaining data points. Concerning fertilizer recommendations, lower critical values would consequently lead to lower nutrient demands analyzed and to lower resulting recommendations. This bears of course environmental implications.

For N, however, critical values calculated by DRIS were lower than determined by BOLIDES. One explanation in this case is, that among the 15 % best performers, the dilution effect resulting from a sufficient supply of nitrogen in soil leads to a reduced nitrogen concentration in plant tissue. In the evaluation with BOLIDES, all plant / yield data sets participate and, depending on the extent of outlier removal, also plants with higher concentrations on nitrogen will be included in the determination of the critical value.

In comparison to the date cited in literature with respect to *Gossypium hirsutum* (Tab. 8.3 and 8.4, Annexe), most of the values deduces by means of BOLIDES were right in the center of the range described by other authors; this was the case for N, P, Ca, Mg, Cu, B. Concerning other elements, the values deduced using BOLIDES were high in comparison with the reference data; this was the case for S, K, Fe, Mo. Critical values of other elements determined in the present study were low in comparison with the data in literature; this was the case for Mn and Zn. There are two explanations for the tendency outlined above: First, regional influence on the deduced critical values may have to be considered, as explained under “Regional boundary lines and critical values” in chapter 5.1.1. Secondly, there may be an influence of species (*Gossypium barbadense*) and variety (in Egypt, exclusively local GIZA-varieties are cultivated).

Tab. 5.1: Critical values for organically grown cotton (*Gossypium barbadense*) in Egypt according to BOLIDES and DRIS in comparison with reference data for *Gossypium hirsutum*.

Method	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo
	[%]	[g/kg]					[mg/kg]					
BOLIDES	4.1	3.4	8.9	30.6	26.8	5.8	272.6	54.2	25.1	11.1	44.5	1.59
DRIS	3.6	3.6	9.3	35.5	26.9	5.9	363.9	55.6	31.5	13.0	46.6	1.9
Literature*)	3-4.5	2-6.5	2.5-8	9-35	6-40	3-9	30-300	25-350	50-300	5-25	20-100	0.5-2

*)Tab. 8.3 and Tab. 8.4, Appendix

In addition to the critical values as determined using BOLIDES-method, a functional relationship between nutrient concentration in plant tissue and yield was established for all nutrient concentrations in plant tissue (Tab. 4.2). These equations signify the yield which can be attained in relation to a certain plant nutrient supply (indicated by value of the tissue analysis) under most favorable conditions. With respect to BOLIDES, Tab. 5.1 lists the maximum value of these equations. In order to have some comparability, these are compared to the mean values of the best 15 % of the population, as far as cotton production figures are concerned, as proposed for DRIS.

Methods for the deduction of critical values were assessed by other authors as follows: Walworth et al. (1985) compared the boundary line approach with the DRIS-method and concluded, that the optima determined by both methods revealed only small differences, indicating that either method is acceptable for estimating critical values. Poovarodom and Chatupote (2002) stated, that the results obtained by the boundary line approach was consistent with tentative standard values, established using a minimum variation range of leaf nutrients.

5.2 Methodical approach for the evaluation of individual plant data

The theoretical background and the differences between the univariate, bivariate and trivariate approach for the evaluation of individual plant data was explained in chapter 2.3.

One basic difference between the PIPPA-approach and the evaluation methods DRIS and CND is, that PIPPA employs a non-linear relationship between nutrient supply (represented by the nutrient concentration in leaf tissue at a certain sampling time) and yield. PIPPA thus follows the “law of the diminishing yield increment”, which was discovered by Mitscherlich[2] (1909). This implies, that with PIPPA stronger deficiencies are assessed as even more serious and minor deficiencies are judged as less important.

DRIS and CND basically presume a linear relationship between nutrient concentration and yield and compare nutrient concentrations in a sample with the corresponding critical values (mean concentrations in a high yielding subgroup, Fig. 5.2). However, as both systems concentrate on the interdependence of nutrients in plant tissue for the execution of physiological processes, the actual nutrient concentration to be analyzed is set in relation to all other plant nutrients analyzed and to their corresponding critical values. In consequence, these procedures lead to a levelling of index values. Additionally, in the CND-approach, the nutrient concentrations are set in relation to their geometric means and log-ratios are deduced, which results in an even further levelling of index values.

[2]Consequently, the Mitscherlich boule could be used as boundary line to be fitted to the step fuctions as boundary line. In this case, however, there would be no distinct maximum value.

In the following chapter, the differences in the results obtained by the three systems for the evaluation of plant data shall be outlined. For this reason the nutritional status of all 207 plant data sets were evaluated using the methods of PIPPA, DRIS and CND. In addition to the actual approach of PIPPA, which is focussed on the diagnosis of nutrient deficiencies, excess plant tissue element concentrations were calculated with respect to the critical values determined by BOLIDES. Results of these evaluations are listed in Tab. 8.23 (PIPPA), Tab. 8.26 (excess element concentration with reference to BOLIDES), Tab. 8.29 (DRIS) and Tab. 8.32 (CND). The results are depicted as well as stapled bar charts in Fig. 4.12 (PIPPA), Fig. 8.8, Appendix (excess element concentration with reference to BOLIDES), Fig. 8.9 (DRIS) and Fig. 8.10 (CND).

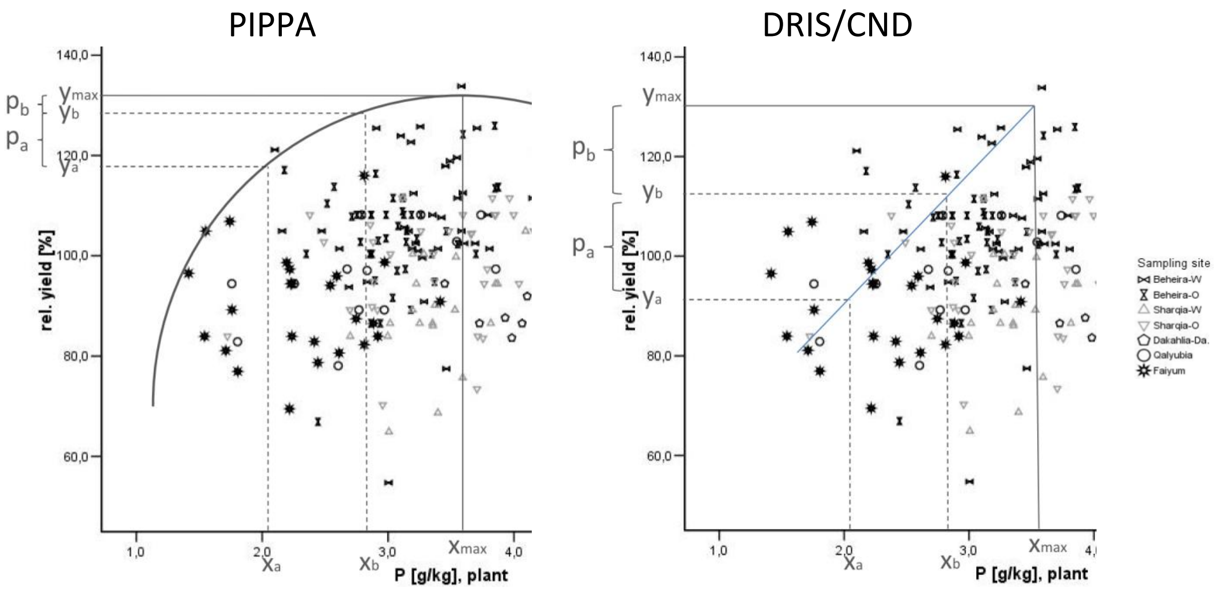


Fig. 5.2: Relation beween plant tissue concentration and yield employed by PIPPA in comparison to DRIS and CND.

Seperately for deficiencies and surplus, mean indices were calculated with respect to the different sampling regions and listed in Tab. 4.18 (deficiencies) and Tab. 4.20 (excess). Concerning the regional deficiencies, diagnoses of the three systems are visualized in a matrix (Tab. 4.19). Concerning the different sampling regions, the following methodical differences and similarities in the evaluation by PIPPA, DRIS and CND can be deduced from the above-listed charts.

Beheira

Generally, deficiencies diagnosed in plant tissue from the Beheira governorate are minor, in comparison to plant material from other regions examined. The number of deficient elements diagnosed per sample was much less using PIPPA than using DRIS or CND. With all methods, deficiencies were in tendency stronger and more numerous at Beheira-O than at Beheira-W. Deficiencies of Fe, Mn, Zn, Cu and B were diagnosed using DRIS and CND. Fe was diagnosed as being strongly deficient by DRIS-evaluation. Deficiencies of N, P, S, K and Mg were assessed strongest by CND, followed by DRIS and PIPPA.

Excess supply for Beheira was diagnosed especially for Mo, but also for B, Cu, Zn, Mn, Ca, Mg and S by DRIS, CND and calculated on the basis of critical values determined by means of BOLIDES.

Sharqia

As far as Sharqia is concerned, a similar range of minerals was evaluated as deficient by the three evaluation system: S, K, Mo were mostly in need, but deficiencies were also diagnosed for N, P, Ca, Mg, Cu, Zn and B. Zn was stronger in focus using DRIS- and CND-evaluation. N-deficiencies were estimated gravest by PIPPA. Generally, deficiencies at the Sharqia governorate seem to be estimated as gravest by CND.

Concerning leaf tissue samples from Sharqia (W and O), Fe was diagnosed as being in excess by all evaluation systems. Additionally, at Sharqia-W the elements N, P, Ca, Mg and Zn were diagnosed being in surplus by all systems. At Sharqia-O, Mn and, to a smaller extent B, were diagnosed exceeding the plant demand.

Dakahlia/Damietta

Only eight samples originated from this region. They were diagnosed similarly by all three systems: N, S, K, Mn and Mo were determined as most deficient. N and S deficiencies were judged less severe by DRIS than by the other two evaluation systems.

At Dakahlia, the most pronounced excess supply was determined concerning Fe by all systems applied, followed by P. The evaluation systems DRIS and CND diagnosed N and S as deficient, too.

Qalyubia

The fourteen tissue samples originating from Qalyubia were diagnosed most deficient by all systems concerning P, S, K and Mo.

Excess supply was measured by the three evaluation systems above all with respect to Fe, but also concerning the other micronutrients B, Mn, Zn and Cu.

Faiyum

Strong deficiencies for P and Cu were diagnosed by all three evaluation systems. Additionally, a lack of K, Ca, Mg, Zn and Mo was diagnosed by the systems DRIS and CND. Additionally, CND diagnosed deficiencies for S and N in all samples originating from Faiyum.

With all systems, a large over-supply with respect to Bo, Mn and Fe was analysed for Faiyum.

From this brief overview it can be concluded, that the different systematic approaches by PIPPA, DRIS and CND result in different characteristics concerning the evaluation of deficiencies: The number of nutrients identified as deficient is less with PIPPA and higher with DRIS and CND. A levelling of deficiency values can be observed from PIPPA over DRIS to CND: CND-indices vary much less from each other than PIPPA-indices.

Furthermore it is quite obvious, that elements which were determined being in surplus at Beheira were evaluated as deficient in leaf tissue samples from the other sampling sites. This observation goes along with the fact, that high yielding plots were concentrated in one area, i.e. the sampling sites at Beheira (see Fig. 4.3 and also chapter 4.5.4, Regional variation). With no method it can be avoided that elevated leaf tissue concentrations, which possess no physiological yield effect, coincidentally occur at high yielding sampling regions and thus are considered for the calculation of critical values. It can however be assumed, that with an increasing number of samples, available from a range of different high yielding regions, this problem will diminish.

At the present stage of the investigations, no further assessment of the different evaluation methods is reasonable. The evaluation of the nutrient status of the crop and the related yield performance is only one step towards recommendations on crop cultivation practice and fertilizer use. Only by means of an assessment of fertilizer recommendations, based on the evaluation systems PIPPA, DRIS and CND, the relative excellence of the systems may be determined more thoroughly.

However, comparisons of systems were carried out by a number of different authors:

A comparison between the results of the CND-approach and the DRIS-approach was executed for sweet corn (Khiari et al., 2001b) and potatoes (Khiari et al., 2001c). The authors found a close relationship between the DRIS- and CND-values.

Casanova et al. (1999 and 2002) showed, that the boundary line approach allows the quantification of yield reductions with respect to the best performing field. It provides information in order to decide, if investigations to increase yield are justified and enables to predict yield performance.

Rubio et al. (2003) tested with a nutritional experiment on the aquatic plant *Lemna minor* the "Law of the Minimum" (univariate approach) against the "multiple limitation hypothesis" (trivariate approach). The authors concluded, that a "nutrient-specific" analysis, which is comparable to the evaluation System BOLIDES/PIPPA, considering the biology of each mineral nutrient rather that grouping plant resources as a whole, is more appropriate in understanding plant response to nutrient availability than general models.

5.3 Critical values deduced by BOLIDES in comparison to data in literature

The cotton plant is known as salt tolerant (Oosterbaan, 2003), requires sun and sufficient water. Its large taproot and a widespread root system benefit from a deep soil profile (Unruh and Silvertooth, 1996a and 1996b). As taproot crop, cotton does not well exploit the top soil, especially when the soil dries out in between irrigations (McMichael et al., 2010). As the nutrient supply of the cotton plant is dependent on the depth of the root system, which itself is effected by the profoundness of the soil profile, a soil sample from the top 20 or 30 cm can only mirror one aspect of the nutrient supply of the plant.

By taking leaf tissue samples, the plant itself turns out to become the monitor of its supply with nutrients. Nutrient concentration in plant tissue is not only affected by the concentration of the nutritional elements in the soil but also from various physical factors, like depth of the profile (which is limited by high water tables and hardpans) and water supply. Nutrient concentration in plant tissues monitors the competition of minerals in the plant root area, too. Sillanpää (1982) considered plant analysis, since the process of absorption is taking place under the laws of nature, as the most reliable measure of the fraction of minerals available to plants whereas he regarded soil analysis as an attempt to imitate plants.

The date of sampling plant tissue orientates at the state of plant development of the cotton plants, when the root system has established and bolls begin to develop (McMichael et al., 2010). Critical values therefore indicate the physiological potential of the plants at a certain state of growth to accumulate sufficient minerals to accomplish a high yield.

Below, critical values determined by BOLIDES, i. e. the maximum values of the curves determined as boundary lines for the leaf tissue concentrations of nutrients / relative yields are discussed and compared to reference data on critical values (Tab. 8.3 and Tab 8.4).

5.3.1 Nitrogen

The critical value determined by DRIS (3.6 % dm) was lower than that calculated according to BOLIDES (4.1 % dm). Data in literature range from 2.1 to 5.4 % dm. Critical values for nitrogen were reported to be higher for older than for younger varieties due to a changed habit of partitioning, transferring higher amounts of nitrogen to the bolls in a reduced length of season (Bell et al., 2003). As the species *Gossypium barbadense* shows a stronger vegetative growth (Unruh and Silvertooth, 1996a and 1996b) and has been less transformed by plant breeding than *Gossypium hirsutum*, it is possible that this may explain a relative high critical value for nitrogen. Very low critical values, indeed, were reported due to dilution effects (sampling of the whole shoot) (Soomro and Waring, 1987) or due to nutrient deficiencies (Dagbenonbakin, 2005). In the present investigation, the critical N-value determined by BOLIDES was relatively constant over the years and the sampling regions (see chapter 4.5.4, Variation in different years, Regional variation) and thus is suitable for further application.

Bell et al. (2003), who determined regional and year-specific critical deficiency values for nitrogen over 4 states and 13 sites discovered, that critical values at early bloom varied (1996: 39-46 g/kg dm; 1997: 34-47 g/kg dm) and gave the following explanations: unusually low critical values occurred due to extended droughts, unusually low or high critical values occurred due to site-specific abilities to replenish nitrogen to the crop, unusually high critical values could be detected after high N-application and was also peculiar for irrigated cotton. The authors further suggested that there was an influence of the variety.

One possible reason for the differences in critical values determined by various authors may be the pattern of nitrogen concentration and partitioning in the cotton plants examined. N-concentration in leaves at lower positions may be lower than in the youngest fully matured leaf. Main stem (monopodial) leaves may have another N-concentration than leaves on fruiting branches (sympodial). Furthermore, redistribution takes place especially from N assimilated in main stem leaves towards generative plant organs. This is especially the case for modern, high yielding varieties, which in a season of reduced length can transfer higher amounts of nitrogen to the bolls. Therefore, the location of the sampled tissue may be of influence on the height of the critical value (Bell et al., 2003).

5.3.2 Phosphorus

The critical P-value for *Gossypium barbadense* determined by DRIS (3.6 g/kg) was higher than deduced by BOLIDES (3.4 g/kg), presumably due to the outlier reduction procedure carried out with the BOLIDES-method. It did not change over the years (see chapter 4.5.4, Variation in different years). The low yielding sampling site Sharqia exhibited slightly higher concentrations than the high-yielding site Beheira, which indicates, that other nutrients or growth factors, like water, were limiting (see chapter 4.5.4, Geographical variation).

The values determined by use of BOLIDES were within the range for critical values found in literature for *Gossypium hirsutum*. These reference data show in recent years a tendency towards a reduced critical deficient level, presumably as a result of breeding activities. Critical deficiency levels, determined in nutrient solution, are different according to the varieties (Medeiros and de Haag, 1990). Phosphorus concentration in leaves is also reported to be depending on temperature. On high P soil, a positive correlation was observed between the concentration in the youngest fully unfurled leaves and mean diurnal temperature (Dougall and Kahl, 2007). It was also obvious, that P-concentrations in the leaves did not change according to the amount of fertilizer used (between 0 and 100 kg P/ha), but differed with sampling time and kind of sampled leaves. The youngest, fully unfurled leaves showed higher concentrations with less variability than the youngest, mature leaves. Concentrations in both groups were higher at the early state of plant development and decreased later.

The critical P-value determined by BOLIDES however, was quite constant over the years (see chapter 4.5.4, Variation in different years) and therefore seems suitable for conducting further evaluations.

5.3.3 Sulfur

The critical value for S, determined for *Gossypium barbadense* by DRIS (9.3 g/kg), was more elevated than the one determined using the BOLIDES-approach (8.9 g/kg).

In *Gossypium hirsutum,* critical values for sulfur were determined only a few times: Jordan (1964), Jones (1989), Malavolta et al. (1987) and Dagbenonbakin (2005) determined values between 2 and 4 g/kg dm. Mills and Jones (1996) and N.N. (2009) specified ranges of 2.5 to 8 respectively 10 g/kg S dm.

With this background, the critical values determined in the present study are located “at the top end of the scale”. An explanation of this phenomenon may be found with the high sulfur concentrations in the soils of the Beheira governorate, which are due to salinization and sea water intrusions in the coastal region. Elevated sulfur leaf tissue concentrations in the high yielding cotton plants of the region are the consequence, suggesting a need for S for which there is no physiological necessity (Fig. 8.3, Appendix). Neither further critical values for S in *Gossypium barbadense* have been determined nor even any field experiments exist which refer to the nutritional status of sulfur (Tab. 8.5). Therefore a need for research is apparent, concerning a verification of the critical value for S. This would include broadening the coverage of plant tissue analyses towards sampling regions with elevated yields and a low to moderate supply with sulfur.

5.3.4 Potassium

With DRIS, a higher critical value for K was determined (35.5 g/kg) than with BOLIDES (30.6 g/kg). Both values are, compared with the numerous international values established for *Gossypium hirsutum*, rather on the “right side of the scale”. As discussed for sulfur, mean values for potassium in soils and plant tissues were high at Beheira and low at the other sampling regions (Fig. 8.3, Appendix). Whereas no critical values have been determined for *Gossypium barbadense*, more information as a result of field experiments, even including local “GIZA” varieties, is available (Tab. 8.5). While Fawzi et al. (1987) found average values of 21.3 (14-30) g/kg dm in Dakahlia and of 33.8 (20-50) g/kg dm in Minia and El-Fouly et al. (1997) analysed average values of 21.7 (13-35) g/kg dm in Kafr El-Sheik and 20 (12-29) g/kg dm in Beni-Swef, other authors reported lower values in connection with fertilizing tests: El-Sayed (1997) measured 18-24 g/kg dm K at fertilization rates of 150-220 kg/ha N, 16 kg/ha P and 47.3 kg/ha K and different additions of micronutrients (Fe, Mn, Zn). Nofal et al. (2002) detected 2-14 g/kg dm K at fertilization rates of 133 kg/ha N, 23.6 kg/ha P and 47.4 kg/ha K and additions of Fe, Mn and Zn. Kassem and Ahmed (2005) found 10.4-16.3 g/kg dm K at fertilization rates of 143 kg/ha N, 24.3 kg/ha P and 0 to 95 kg/ha K.

With reference to the fertilizer experiments cited above, a likely explanation for the higher concentrations of potassium, besides the regional effect of the high yielding sites at Beheira, can be found in the influence of organic fertilization. As less mineral N is available to the plant, vegetative growth is limited and therefore a relatively elevated concentration of K could be measured. This can especially be the case for *Gossypium barbadense* varieties, as they tend even more to vegetative growth at an elevated supply-level with mineral nitrogen (Unruh and Silvertooth, 1996a, 1996b). Reddy et al. (2000) determined the physiological critical value for *Gossypium hirsutum* with respect to photosynthesis at 21 g/kg K dm and for leaf growth at 25 g/kg K dm. Despite these determinations the authors recommended a target value of 30 g/kg K dm in order to buffer shortages later on in boll development.

The critical value deduced by BOLIDES in the present study with 30.6 g/kg dm and little variation over the years (chapter 4.5.4, Variation in different years) appears due to the above-cited reason – in order to buffer shortages – acceptable.

5.3.5 Calcium

Critical values for Ca were almost identical irrespective of the method of determination (DRIS: 26.9 g/kg, BOLIDES 26.8 g/kg). Data in literature regarding *Gossypium hirsutum* vary between 6 and 40 g/kg dm, but most values are grouped between 20 and 30 g/kg dm. No data on Ca concentrations for *Gossypium barbadense* are available. From the soil data evaluated it is anyhow clear, that the soils of the high yielding governorate Beheira are well supplied with Ca, and the cotton plants cultivated there are the same (Fig. 8.3, Appendix). Critical values determined for Ca do not show large variances over the sampling period (Fig. 8.6, Appendix), another reason why they seem suitable for further evaluations.

5.3.6 Magnesium

Critical values for Mg were with 5.9 respectively 5.8 g/kg dm practically identical, independently whether determined by DRIS or BOLIDES. Concerning *Gossypium hirsutum*, there are numerous reference data on critical values available, ranging from 2 to 9 g/kg dm, with most values concentrating between 3 and 9 g/kg. In a field experiment with *Gossypium barbadense*, Nofal et al. (2002) detected 3.3-7.2 g/kg dm Mg at fertilization rates of 133 kg/ha N, 23.6 kg/ha P and 47.4 kg/ha K and additions of Fe, Mn and Zn. Critical values determined for Mg do not show large variance over the sampling period (Fig. 8.6, Appendix). Therefore it can be assumed that the determined critical value is appropriate.

5.3.7 Iron

The critical value for Fe, determined with DRIS, was with 364 mg/kg dm considerably higher than the one determined by the boundary line method with 273 mg/kg dm. Data in literature for *Gossypium hirsutum* range between 40 and 300 mg/kg dm, so at least the value determined by DRIS is located outside these limits. Other authors determined high values for iron in *Gossypium barbadense* in on farm experiments in Egypt, too: Fawzi et al. (1987) measured 823 (370-983) mg/kg dm Fe at Dakahlia and 504 (131-1051) mg/kg dm Fe at Minia. Lower values were also cited from field and on farm experiments in Egypt: El-Fouly et al. (1997) determined 162 (71-240) mg/kg dm Fe. Even with an application of a micronutrient spray containing iron, El-Sayed et al. (1997) only attained values of 187 mg/kg Fe but Nofal et al. (2002) measured 281 to 583 mg/kg dm when applying Fe respectively a compound fertilization of Fe, Mn and Zn.

According to the present study, concentration of Fe in soils and in leaves was less in the samples of Beheira than in the tissue samples originating from other regions (Fig. 8.3, Appendix). The washing of some leaves collected at Faiyum revealed, that Fe was, to a high percentage, located on their surfaces: mean value of Fe for unwashed leaves was 643 mg/kg dm whereas for washed it was only 207 mg/kg dm (Tab. 3.3). Comparable observations were reported by Sillanpää (1982) in the 80s, when he was trying to evaluate world-wide collected tissue samples; he therefore discarded all analyses of Fe in tissue samples. However, the determination of local critical values in the present study revealed, that at the high yielding region Beheira, the local critical value (of unwashed leaves) amounted to 321 (196-445) mg/kg dm whereas at Sharqia, where yield performances were less satisfying, it amounted to 556 (143-1254) mg/kg dm (see chapter 4.5.4, Regional variation). It therefore can be assumed, that besides the contaminating effect of Fe, there may also exist a local effect on the yield level. As the outlier removal before starting the boundary line procedure was somewhat arbitrary (see chapter, 5.1.1, Outlier reduction) it seems reasonable to cut down this value even further.

5.3.8 Manganese

Concerning manganese, critical values determined by means of DRIS (55.6 mg/kg dm) and by BOLIDES (54.2 mg/kg dm) do not show much difference. On the contrary, critical values in literature referring to *Gossypium hirsutum*, vary between 10 and 500 mg/kg dm, with most of the values ranging between 30 and 300 mg/kg dm. Very low critical values were often determined in plant experiments with nutrient solutions and/or were judged according to visible deficiency symptoms (Dordas, 2009). With foliar application of manganese, he measured concentrations of manganese between 46 and 72 mg/kg dm and supposes a critical value for manganese at that level.

In field experiments with *Gossypium barbadense*, Fawzi (1987) determined Mn concentrations of 96 (55-115) mg/kg dm at Dakahlia and of 73 (40-98) mg/kg dm at Minia, El-Fouly et al. (1987) measured 75 (34-130) mg/kg dm at Kafr El-Sheikh and 50 (15-99) mg/kg dm at Beni-Swef. With an application of a micronutrient spray containing manganese, El-Sayed et al. (1997) determined concentrations up to 47 mg/kg Mn in cotton leaves and Nofal et al. (2002) measured 62 to 145 mg/kg dm when applying manganese respectively a compound fertilization of Fe, Mn and Zn. The determined critical value for manganese therefore seems to be suitable for further evaluation.

5.3.9 Zinc

The critical value for zinc was determined as 31.5 mg/kg dm by DRIS and as 25.1 mg/kg dm using the boundary line method. Data in literature for *Gossypium hirsutum* vary broadly between 11 and 300 mg/kg dm with low values determined in nutrient solutions and judged according to visible symptoms only. Most of the values therefore range between 20 and 40 mg/kg dm. At on farm experiments with *Gossypium barbadense*, Fawzi et al. (1987) determined means of 44 (18-47) mg/kg dm for Dakahlia and 45 (21-122) mg/kg dm for Minia, El-Fouly et al. measured only 22.5 (13-30) mg/kg dm in Kafr El-Sheikh and 15 (2-33) mg/kg dm in Beni-Swef. With an application of a micronutrient spray containing zinc, El-Sayed et al. (1997) determined concentrations between 20 and 32 mg/kg Zn in cotton leaves and Nofal et al. (2002) measured 21 to 72 mg/kg dm after the application of zinc respectively a compound fertilization of Fe, Mn and Zn.

The critical Zn values determined in the present study were rather constant over the years (Fig. 8.6, Appendix) and therefore seem appropriate for further use.

5.3.10 Copper

Critical values for copper in *Gossypium barbadense* leaves were determined at 13.0 mg/kg dm with DRIS and at 11.1 mg/kg dm with BOLIDES. Critical values in literature concerning *Gossypium hirsutum* are cited to be between 4 and 25 mg/kg dm. Fawzi et al. (1987) measured Cu concentrations in *Gossypium barbadense* of 12 (5-15) mg/kg dm at Dakahlia and of 14 (7-18) at Minia, which is comparable to data analysed by El-Fouly et al. (1997) with 14.1 (7-19) mg/kg dm at Kafr El-Sheik and 6 (2-15) mg/kg dm at Beni-Swef. In fertilizing experiments using single and compound micronutrient fertilization with Fe, Mn and Zn, El-Sayed et al. (1997) measured 8-11 mg/kg and Nofal et al. (2002) determined 7-25 mg/kg dm Cu. The critical values determined for Cu using the BOLIDES-approach differed over the years (Fig. 8.6, Appendix), a reason to launch further investigations.

5.3.11 Boron

In the present study boron critical values were determined with respect to *Gossypium barbadense* at 46.6 mg/kg dm using the DRIS methodology and at 44.5 mg/kg dm according to BOLIDES. Reference data concerning *Gossypium hirsutum* vary from 15 to 146 mg/kg dm, with most indications being between 20 and 60 mg/kg dm. In field experiments conducted by Dordas (2006), with 0 to 1,200 mg/l boron as foliar fertilizer concentrations in cotton leaves between 30 and 85 mg/kg dm were attained. Boron foliar application significantly affected seed yield, yield components and seed germination of cotton. The significant influence B had on seed yield and yield components showed the importance of this micronutrient for seed formation. Together with its phloem-immobility, these physiological functions explained the high value of the critical B level of 53 mg/kg dm determined by Dordas (2006). This is a much higher value than the critical value of 20 mg/kg dm, proposed by other scientists and deduced from plant experiments under growth chamber conditions by evaluating CO_2-exchange rates and assimilate transport from leaves to fruit. The reduced transport of assimilates resulted in a decrease of biomass production and an increase of fruit abscission (Zhao and Oosterhuis, 2002).

No data on boron in cotton tissue are available for *Gossypium barbadense*. Critical values determined in the present study for B over the years were identical (Fig. 8.6, Appendix). The critical value for B, as deduces by BOLIDES, therefore seems reasonable but needs affirmation through further research.

5.3.12 Molybdenum

Critical values for molybdenum were determined as 1.9 mg/kg dm using the DRIS-approach and as 1.59 mg/kg dm by use of the boundary line method. Concerning *Gossypium hirsutum,* critical values in literature range from 0.5 to 2.4 mg/kg dm. No data are available concerning Mo in tissue of *Gossypium barbadense*. As explained with respect to B, the critical value deduced in the present study by means of BOLIDES needs affirmation through further research. This also includes factors influencing variations over the years, as the critical value deduced in the present study revealed variability in this respect.

5.4 Soil-plant interactions

From the statistical analysis of soil and plant data in chapter 4, it could already be concluded, that in the present study soil analysis did not give sufficient information on the nutrient supply status of the cotton crop. In addition, nutrient concentrations in plant tissue samples have proven more suitable for the deduction of critical values than the corresponding soil data: the values in plant tissue show a greater tendency to follow a normal distribution, therefore the deduction of corresponding critical values is of higher representativeness; in other words: the plant itself is the better monitor for its own nutrient supply than soil analysis.

In the following chapter, soil-plant interactions and reasons for the low soil-plant correlation for nutrients will be discussed.

5.4.1 Soil physical properties

Texture analyses according to Durner (2008) have revealed that all examined soils were fine textured. While soils at the Sharqia governorate showed a very high proportion of clay minerals, a larger silt-fraction was identified in Dakahlia/Damietta and Qalyubia whilst soils at the Beheira governorate often showed a sandy fraction. The stability of the soil structure was in consequence best at Beheira governorate, where the soils were far more friable. In Vertisols, which can be found in Sharqia and Qalyubia governorate, cracking and a constant turnover of soil particles due to the high clay-concentration can frequently be observed (FAO, 2006). The dominating expanding clay minerals and a heavy texture result in a narrow range between moisture stress and water excess (Fiedler, 2004). The cultivation of Vertisols is therefore difficult and plants grown there might also suffer mechanically, i. e. during seed germination. Generally, Nile delta soils consist of a deep soil profile, the usability of the soil depth can however be limited due to shallow groundwater layers and hardpans, as Belal (2006) reported from some fields investigated at the Sharqia governorate.

The pH-value is categorized, with a mean value of pH 7.91, as slightly to medium alkine and does not differ significantly between the regions. The reduced availability of, P, Fe, Mn, Zn, Cu and B at this pH-level (Lippert, 2000) was also visible as negative correlation between pH-value and a range of elements (Tab. 4.7).

5.4.2 Organic carbon and nitrogen

Mean concentrations of soil organic carbon was determined for Beheira-W at 1.4 % and for Beheira-O at 1.5 %. All other sampling regions contained far less soil organic carbon: Sharqia-W 1.1 %, Sharqia-O 0.7 %, Dakahlia-Da. 1.2 %, Qalyubia 0.9 % and Faiyum 0.8 %. These figures correspond well with the values determined in the seventies and eighties of the last century for alluvial Egyptian soils by Sillanpää (1982) with 1.2±0.3 % and by El-Fouly (1984) with 0.8-1.4 %. One explanation for these differences between the sampling regions is, that especially at the Beheira governorate, the preparation and application of compost has been intensively propagated by the extension staff of NATURETEX (Bordeny, 2010).

The influence of C_{total} and C_{org} on yield performance is positive (Tab. 4.5), one proof for the role of organic carbon as part of organic matter with respect to humus in soils as a storage facility for water and as a slowly flowing nutrient source. C_{org} in soils shows a strong positive correlation to a number of nutrients: C_{total}, N_{total}, P_{Olsen}, K_{CAL}, K_{LE}, Zn_{LE} and Cu_{LE} (Tab. 4.7).

Plant and soil carbon concentrations showed a negative correlation (with C_{total} -0.5 and C_{org} -0.28) on a high significance level (p<0.01). Sufficient humus indicated by an elevated C_{org}-concentration would prevent plants suffering from water shortages and thus decrease C-concentrations in plants. Humus as a slow flowing nutrient source would also protect plants from nutrient shortages: imbalanced nutrients may lead to an increase in dry matter concentrations. The elevated C-value in plant tissues from the governorates Sharqia, Dakahlia-Damietta and Qalyubia (all mean concentrations above 42 %) in comparison to the low concentration at Beheira and Faiyum (all ≤ 41.1 %) therefore are an indication for water stress or an imbalanced nutrient supply. Mean plant carbon concentration fluctuated from 2008 (41.0 %) to 2009 (42.2 %) and 2010 (41.3 %) which indicates water scarcity in 2009.

Mean total nitrogen in soils amounted to 0.094±0,056 % dm, which is slightly lower than values determined by Sillanpää (1982) and El-Fouly (1984) around 30 years ago. With circa 0.13 % N in soils, Egypt in those days was ranking at medium international level (Sillanpää, 1982). As the present study includes only farms run according to organic principles, the renouncement of mineral N-fertilizer, as demanded by the certification standards for “organic” or “demeter” quality, might be one reason for the low N-level.

In comparison to the other regions, soils of the Beheira governorate and their corresponding plant tissues showed elevated mean N-values (Fig. 8.3). Analysis according to two-way ANOVA revealed a significant influence of year and region on N concentration in soil and plant tissue (Tab. 4.2 and Tab. 4.4). Soil nitrogen had a significant but small influence on yield (Tab. 4.5). An main source of nitrogen in organic farming is soil organic matter. This is the reason why N_{total} reveals a strong correlations to total and organic soil carbon but also to other macro- and micronutrients (Tab. 4.7). Practically no positive correlation (except for Mo) was found between soil N and plant parameters. This is most probably due to an instant plant response in case of increased N supply and resulting dilution effects on other nutrients in plant tissue. Bell et al. (2003), Fridgen and Varco (2004) and Fritschi et al. (2004) report, that up from the early flowering stage, cotton rapidly increases (vegetative) growth when nitrogen is available, so that nitrogen concentration of leaf tissue would not increase with growing nitrogen supply.

5.4.3 Electrical conductivity and the cations sodium, potassium, calcium and magnesium

Values for electrical conductivity as well as for Na were particularly high in soils of the northern governorates Beheira (west and east) and Sharqia (west) (Fig. 8.3, Tab. 8.17, Appendix). Electrical conductivity was strongly (correlation coefficient>0.6) and high significanty (p<0.01) correlated to the concentrations of, S_{LE}, Ca_{LE}, Mg_{LE}, B_{LE} and Na, elements which are components of the salts in soils. These findings correspond with the categorization of the soils in the northern delta as Solonchaks according to FAO-typisation (Hammad, 1976).

As explained by Oosterbaan (2003), sea water intrusions are a main cause of salinization in the coastal region of the delta, but man-made reasons are of serious importance, too: with the completion of the Assuan High Dam in 1970, annual flooding of the fields in the Nile valley and delta ceased. These floods had regularly counteracted the salinization process. In order to control waterlogging and salinity, a national drainage program has been carried out for decades and in 2003, about 3 m ha of the irrigated area were drained (FAO, 2010). Anyhow, to overcome severe water-shortages, the re-use of drained water has become of increasing importance and even became part of a national water resource management plan (Ministry of Water Ressources and Irrigation, 2005a and 2005b). The official way is the mixing of saline drainage water with fresh canal water at designated points across the upper order canals and drains. At a micro-level, whenever a shortage occurs, farmers unofficially pump drainage water directly into their fields or they transfer drainage water into tertiary irrigation canals (Belal, 2006). Severe water shortages and pollution problems were reported from different sampling sites in Egypt (Al Jazeera, 2007 and 2009). According to analytical data on the water quality of various sources originating from aquifers, the Nile, irrigation channels and drainage systems (Ali et al., 2000; Belal, 2006; Bloem, 2011; Elawa, 2010; Taha et al., 2004) a considerable amount of salts can be transferred into agricultural land by use of contaminated irrigation water (Klages, S., Schnug, E., 2012b).

In the present study, a correlation between Na in soils and plant tissues existed at a significance-level of 0.05 (Tab. 4.7). But Na-concentrations in plant tissues did not follow the allocation patterns for Na in soils of the different regions: not at Beheira, but at Faiyum the by far highest Na concentrations were determined with 3.51 mg/kg dm in plant tissue, that was circa four times the concentration in tissue from Sharqia and 20 times of the one of Qalyubia (Fig. 8.3 and Tab. 8.17,, Appendix). Samples from the high yielding site Beheira, despite highest mean values for electrical conductivity and Na in soils, only exhibited mean concentrations in plant tissue of around 400 mg/kg dm.

Na ranks among the factors influencing cotton yield performance (Tab. 4.5). Regression analysis revealed that with the Na concentration in soils concentrations of S and Ca in plant tissue could be explained (Tab. 4.8). Statistical analysis therefore shows that there was a minor negative influence of Na concentration on the yield performance of cotton, an influence of Na on S- and Ca-uptake by plant, but no relation of Na with K, a nutrient of major importance for the cotton plant for obtaining high yields (Tab. 8.1, Appendix).

Over all sampling-sites, the mean concentration of K_{CAL} amounted to 604 mg/kg soil and of K_{LE} to 964 mg/kg dm soil. This is within the frame of CH_3COONH_4-extractable potassium at 535 mg/kg for wheat soils and at 470 mg/kg for maize soils as determined by (Sillanpää, 1982) and of 530 to 830 mg/kg for alluvial soils as determined by (El-Fouly, 1984). In the 80s, Egypt ranked top position in the international comparison concerning soil potassium concentrations (Sillanpää, 1982). Potassium in soil was for both K-fractions considerably higher at Beheira governorate (i.e. K_{LE}: Beheira W 1,650 mg/kg dm, Beheira-O 1,201 mg/kg dm), than in the soils of the other sampling regions (522-731 mg/kg dm). This is surprising, as high concentrations of clay minerals, as can be found especially in the central part of the Nile delta (Sharqia, Qalyubia), usually stand for a high cation exchange capacity and therefore a sufficient supply of the plant with potassium, calcium and magnesium.

Concentration of K in the leaves revealed a comparable distribution pattern to the ones of the soils; high at Beheira (33.3 resp. 36.3 g/kg dm) and Faiyum (31.9 g/kg dm) and low at the rest of the sampling regions (22-25 g/kg dm). Values determined for K in field experiments with *Gossypium barbadense* were often also moderate (Tab. 8.5, Annexe).

The results of two-way ANOVA (Tab. 4.2 and Tab. 4.4) indicate the regional influence: potassium in soil was influenced by year and region, potassium concentration in plant by the region.

The importance of K for cotton nutrition at the state of plant growth (beginning of boll formation) when tissue samples were taken, is underlined by results of correlation analyses: Almost 15 % of the variability of relative yield can be explained by the variability of K_{CAL} and circa 10 % by the variability of K_{LE}. 9 % of the variability of relative yield is explainable by K in leaf tissue (Tab. 4.5). K_{CAL} variability explained 21 % and K_{LE} explained 17 % of the variability of K in cotton leaf tissue (Tab. 4.7). K thus showed the highest positive correlations of all elements for the relations soil/yield, plant/ yield and soil/plant. Potassium in soil was correlated positive to all C- and Ca-fractions in soil, to N, P, Zn_{LE}, B_{LE}, Mo_{LE}, Na and electrical conductivity; i. e. Na in soil increases plant available soil K. A negative correlation was found for pH, Al_{LE}, Cu_{West}, Zn_{West}, Fe_{LE} and $Mg_{Schacht}$, i. e. Al_{LE} decreases plant available soil K (Tab. 4.7). Consequently, potassium in leaf tissue was, as well as potassium in the soil, positively correlated to C_{total} and Ca_{LE} and negatively to $Mg_{Schacht}$, Fe_{LE} and Al_{LE}. N_{total}, P_{Olsen}, Fe_{LE} and Al_{LE} were determined by multiple regression analysis as variables explaining relations between K in plant and soil parameters (Tab. 4.9). These results imply that salinity does not reduce potassium concentration in plants but the abundance of micronutrients and of Al do.

The low concentrations of potassium in the soils of Sharqia, Qalyubia and Dakahlia-Damietta are at first sight astonishing, as the Nile valley and delta are composed of alluvial soils which contain a large proportion of potassium bearing clay minerals (Fig. 4.4). El-Fouly et al. (1997) blamed the construction of the Assuan High Dam, as no replenishment of clay minerals due to the lack of annual flooding took place any more since the dam was completed, particularly as mineral potassium fertilizers are not commonly used in Egypt. On the other hand fertilization with compost in the recommended amounts (see Tab. 8.8 to Tab. 8.11) as well as loaded irrigation water would theoretically furnish the crop with considerable amounts of potassium (Ali et al., 2000; Belal, 2006; Bloem, 2011; Elawa, 2010; Taha et al., 2004, compiled and commented in Klages and Schnug, 2012b). The presence of too many of the mineral ions which are negatively correlated to K in soil and plant ($Mg_{Schacht}$, Fe_{LE} and Al_{LE}) might hamper or even inhibit K-uptake by the cotton plant. Furthermore, reducing conditions in the subsoil might influence the configuration and/or mineral composition of clay minerals (see chapter 5.4.5).

Mean concentration of Ca_{LE} was determined at 28,536 mg/kg soil, which is higher than the mean determined by Sillanpää (1982) using CH_3COONH_4, as an extracting agent and measuring around 5,000 mg/kg dm. Sillanpää (1982) assessed Egyptian soils 30 years ago as extremely well equipped with Ca. In the present study, mean concentrations were highest at Beheira governorate (43,770 mg/kg dm resp. 34,298 mg/kg dm) and Faiyum (39,237 mg/kg dm) and considerably lower in the other regions investigated (12,792 to 20,923 mg/kg dm).

High mean $CaCO_3$-values for Beheira-W with 17.0 %, for Beheira-O with 10.2 % and for Faiyum with 8.6 %, as well as the lower values for the other sampling regions correspond with the above discussed data on Ca_{LE} and the appearance of these soils (Fig. 3.6). They also correspond to figures published by other authors i. e. Fawzi et al. (1987), Abd El-Haleem et al. (2002), El-Fouly et al. (1997), Nofal et al. (2002 and 2010), von Boguslawski (2002) and Sillanpää (1982). Mean calcium concentration in plant tissue amounted to 26.8 g/kg dm. Mean values of calcium are slightly elevated at Beheira (just below 30 g/kg dm) and lower at Sharqia-O and Dahkahlia-Damietta (just above 20 g/kg dm).

Two-way ANOVA (Tab. 4.2, Tab. 4.4) confirms the significant influence of the sampling region for Ca in soil and plant tissue.

The mean value for $Mg_{Schacht}$ ($CaCl_2$ extractable) amounted to 740 mg/kg soil for Mg_{LE} (AAAc-EDTA extractable) to 2,635 mg/kg soil. Sillanpää (1982) found with CH_3COONH_4 as extractant magnesium concentrations of around 1,000 mg/kg, which he judged as extremely well equipped and which is comparable to the level of AAAc-EDTA-extractable magnesium. However, El Fouly et al. (2010) recently compared mean Mg concentrations of alluvial Egyptian soils in 1986 (600-650 mg/kg) with those in 2006 (200-300 mg/kg) and deduced from these figures a prevailing fertilizer need for Mg.

Mean Mg concentration of plant tissue in the present study was determined with 5.8 g/kg dm. Mg concentrations did not differ much over the regions and were lowest at Dakahlia/Damietta (around 5 g/kg dm) and highest at Sharqia-W (above 6 g/kg dm). Two-way ANOVA (Tab. 4.2, Tab. 4.4) shows for Mg_{LE} and $Mg_{Schacht}$ a significant influence of the sampling region and for Mg in plant tissue a significant influence of the year and the sampling region.

While in soils Ca showed positive correlations to all macro- and secondary nutrients, Mg exhibited mostly negative correlations to these elements. Both were strong negatively correlated to Zn_{West} and Cu_{West}, and show a moderate to strong positive correlation to S, B, Mo, Na and electrical conductivity. Al is strong negative correlated to Ca and positive to Mg (Tab. 4.7).

Ca_{LE} variability explained 19 % of the variability of Ca in cotton leaf tissue (Tab. 4.7); after K this is the strongest soil / plant correlation which was detected. Due to the fixation of Ca as carbonates, Ca concentration in plants was negatively correlated to the pH-level. There was a negative correlation with $Mg_{Schacht}$, Fe_{LE} and Al_{LE} in soils which indicates, as discussed for potassium, a certain abundance of cations in the root zone. Mg in plant showed neither positive nor negative correlation to soil parameters, which is logical in case of sufficient plant supply (Tab. 4.8). According to regression analysis, pH and Na are accepted variables to explain the variability of Ca in plant tissue and for Mg it is the pH-level, $Mg_{Schacht}$, Cu_{West} and Al_{LE} (Tab. 4.9). This indicates, that concentrations of Ca and Mg in plant tissue are determined by geological factors but are also influenced by the process of salinization and the presence of competing cations. Irrigation water has to be considered as an important factor influencing the mineral supply in the root zone, with Ca in concentrations of 30-190 mg/l and Mg in concentrations of 12-110 mg/l (Ali et al., 2000; Belal, 2006; Bloem, 2011; Elawa, 2010; Taha et al., 2004, compiled and commented in Klages and Schnug, 2012b).

5.4.4 Phosphorus and sulfur

Phosphorus in soils was determined with different extractants; water (Van der Paauw et al., 1971) extracted the least quantities of P, followed by 0.5 M $NaHCO_3$ (Olsen et al., 1954), AAAc-EDTA (Lakanen and Erviö, 1971) and CAL-solution (Schüller, 1969) as the strongest extractant. The mean value for P_{Olsen} was with 39.1 mg/kg higher than the values determined by Sillanpää (1982) with 13.9 respectively 11.7 mg/kg dm, values which were below average in the international comparison. According to two-way ANOVA, there is a significant influence of year and region on the concentration of P_{CAL}, P_{LE} and P_{Olsen}, a significant site-influence was detected for P_{H2O} and the concentration of P in plant samples (Tab. 4.2 and Tab. 4.4). Both, P_{H2O} and P_{Olsen} in soil and P in plant show a significant influence on cotton yield (Tab. 4.5). The variability of both P-fractions in soil significantly influences phosphorus in plant tissue. The Beheira governorate and – less pronounced – Qalyubia show relatively high P concentrations in soils. Figures are 10fold higher than analysis data from Sillanpää

(1982) in the late 70s, presumably to methodical differences. In cotton plant tissue, highest concentrations were found in soils at Dakahlia/Damietta and lowest in Faiyum soils. Phosphate fixation due to high concentrations of $CaCO_3$ in Beheira soils was most probably the reason for the moderate concentration of P in the corresponding leaf tissues (Tab. 4.8).

High mean sulfur concentrations in soils were measured in the northern part of the Nile delta, at the Beheira governorate (926 and 1,559 mg/kg dm) and Sharqia-W (1,323 mg/kg dm)(Tab. 8.17, Appendix) . No reference data were found concerning concentrations of sulfur in Egyptian soils. Mean concentrations of sulfur in tissue samples was highest at Faiyum (10.33 g/kg dm), followed by the regions near the coast of the Mediterranean, Beheira-W (9.58 mg/kg dm) and Beheira-O (9.13 g/kg dm). Over all samples, there is no significant correlation between S in soils and yield, S in plant and yield (Tab. 4.5) respectively S in soil and plant tissue (Tab. 4.8). Two-way ANOVA revealed for S in soils and plant tissue significant differences between sampling regions (Tab. 4.2 and Tab. 4.4). Mn and Na were determined by multiple regression analysis as variables explaining relations between S in plant and soil parameters (Tab. 4.10). High significant ($p<0.01$) and strongly positive correlation of S with Na, electrical conductivity, B, Mo indicate salinization as source of S, B and Mo in the examined Egyptian soils (Tab. 4.7, see also chapter 5.4.3). Irrigation water may contain considerable concentrations of sulfur (between 4 and 400 mg/l; Ali et al., 2000; Belal, 2006; Bloem, 2011; Elawa, 2010; Taha et al., 2004), which mainly derives from the dissolution of gypsum (El Arabi, 1999). The concentration of sulfur in the aquifers is particularly high and therefore irrigation with water from aquifers might contribute to high sulfur concentrations in soils.

5.4.5 Micronutrients and aluminium

In comparison to data in literature (El-Fouly et al., 1997; Nofal et al., 2010; Kandil et al. 2002), concentrations of Fe and Mn in soils determined in the present study were around 10 fold higher, possibly due to the strength of the extracting agent. In field trials carried out at various regions of the Nile valley and the delta, concentrations of manganese and iron in cotton plants were on the same level as determined in the present study (see Tab. 8.5). In comparison to Sillanpää (1982), who conducted a world-wide survey on the supply status with micronutrients at the end of the seventies of last century, the present data for manganese were 10 fold higher and for iron on the same level. In the international comparison, in those days, the concentration of Fe in Egyptian soils ranked slightly above the average, and Mn considerably below the average (Sillanpää, 1982).

There are no publications which examine the concentration of plant available aluminium. Aluminium concentrations in soils are considerably lower at Beheira governorate than at the the other sampling regions. Concentrations of iron are especially high at Sharqia-W and Dakahlia-Damietta. Soil concentrations of manganese are particularly low at Sharqia-O and Dakahlia-Damietta.

Leaf tissue samples showed low concentrations for Fe at Beheira, and more elevated concentrations in the other governorates. Manganese mean values were particularly low at Sharqia-W and particularly high at Faiyum. As the pre-test revealed, a considerable amount of Fe, and smaller percentage of Mn, could be found on the leaf surfaces from contaminations of dust already at the sampling site or during the handling of the samples (see chapter 3.3.2).

According to two-way ANOVA, Fe, and Mn in soils and Fe and Mn in plant tissue significantly differ between years and sampling sites (Tab. 4.2 and Tab. 4.4).

Al is no plant nutrient. By reason of statistical analyses, Al is nevertheless further discussed in this paper: the variability of relative yield could be explained by almost 8 % by the variability of the concentration of Al in soil (Tab. 4.5). In plants, toxicity symptoms of Al are reported due to chemical reactions with essential nutrients (i. e. the reduced ability of the cotton plant to use P, Ca and Mg in the presence of free Al, possibly as a result of the formation of aluminium complexes in the soil-root interface), the disruption of cell membrane functions (i. e. by changing structure and function of the root cell plasma), the interference with cell division by accumulation in the nucleus, where it forms strong complexes with the nucleic acids and inhibits DNA-sythesis (Hodges and Constable, 2010). Jones (1974) defined the toxicity-level for Al in tissue of *Gossypium hirsutum* tissue as < 200 mg/kg dm. There are indications that the presence of Al in environment is of increasing consciousness in Egypt: Deeb and Gomaa (2011) investigated its concentration in dairy products in Kafr-El-Sheikh and Sallam et al. (2005) tested the negative influence of Al-intake on growth and physiology of rabbits and the protective function of ascorbic acid against Al-toxicity.

At the prevailing pH-level of pH 7.9, Al, Fe and Mn are supposed to be of limited availability. The opposite seems to be the case, Al, Fe, Mn and in some cases other micronutrients often exceed plant needs. One explanation are the reducing conditions in the subsoil under which Fe and Mn are dissolved from clay minerals and released into groundwater (El Arabi, 1999). Elawa (2010) refers to dissolved iron and manganese as nuisance contaminants, common in groundwater sources that are anoxic or anaerobic. A number of authors have recently reported also elevated Al concentration in the groundwater of different sampling sites, released by degrading clay minerals in the subsoil (Buragohain et al., 2010; Frankowski et al., 2011; Marin et al., 2010; Momodu and Anyakora, 2010). Reducing conditions in drainage waters, as reported by Siegel et al. (1994) are an indication for reducing conditions in the subsoil. The transport of the minerals to the top layers of the soil is possible by irrigation water and corresponds with the presence of visible red precipitations on the soil surface after irrigation (Fig. 3.8 and Fig. 3.9). Reducing conditions in groundwater and subsoil are caused by organic pollution due to anthropogenic influence, which results in excess microbial growth and oxygen depletion. Reducing conditions may occur as well during the flooding of rice fields. Due to the shortage of fresh irrigation water, a large proportion of it is reused; it is also carrying an organic load, which may further increase oxygen depletion.

Another explanation is the direct influence of predominant Fe and Al on the other (trace) elements, which might hamper plant's access to competing mineral nutrients. This explanation is supported by results of correlation analysis. In soil, both, Fe and Al were correlated in a negative direction to a number of macro- and micronutrients (Tab. 4.7). Fe_{LE} in soil showed negative correlations to a number of plant nutrients: S, K, Ca, Mn, B and Mo. Al_{LE} is negatively correlated to S, K, Ca, Zn, Cu and Mo in cotton leaf tissue (Tab. 4.8). Multiple regression analysis quite often accepted Fe and Al as explainatory variables for nutrient concentration in plant tissue (Tab. 4.9).

The contamination of leaf surfaces with dust has to be considered when explaining the high concentrations of these minerals in the plant tissue samples, but it is doubtful that the yield reduction can be explained by the obstruction of leaf surfaces only. With reference to the sampling region, the concentration of Fe and Mn in plants reflects the corresponding concentration in soils, except for Faiyum, where the concentrations were highest. Fe shows a comparable pattern for its concentration in soil, lower at Beheira and Faiyum, higher in the soils of the other governorates. Concerning Mn, concentrations in soil were lowest at Sharqia-O and Dakahlia/Damietta. These differences were significant except for Mn in soils (Tab. 8.17).

Concentrations of Zn and Cu show a different distribution in the examined soils as Al, Fe and Mn. Zn and Cu are strong and positively correlated with each other. Especially the Westerhoff-extractable fractions of Cu and Zn show negative correlations to C_{total}, $CaCO_3$, P_{Olsen}, S_{LE}, K_{CAL}, K_{LE}, Ca_{LE}, Mg_{LE}, B_{LE}, Mo_{LE}, Na, el. conductivity. Cu and Zn are positively correlated to Mn_{LE} (Tab. 4.7). There are only a few correlations between Cu and Zn in soil and the plant nutrients (Tab. 4.8), but almost 15 % of the variability in plant tissue concentration of Zn is explainable by the variability of Zn_{West} soil concentration, this signifies one of the highest soil-plant correlation (just below K and Ca). The variability of Cu_{West} explains 7 % and of Cu_{LE} almost 5 % of the variability of Cu in plant tissue (Tab. 4.7).

Cu and Zn exhibit similar distribution patterns over the different sampling regions and in the plant-material: mean concentrations in soils were lower at Beheira-W and Faiyum, and higher at the other regions, mean concentrations in plants did not show much difference. This is apparent from the result of two-way ANOVA, too, which indicated no significant differences for Zn_{LE}, Zn_{West} and Zn plant tissue. For Cu_{West} and Cu in plant tissue, two-way ANOVA indicates significant differences over years and regions, for Cu_{LE} only over regions (Tab. 4.2 and Tab. 4.4). Almost 15 % of the variability in plant tissue concentration of Zn is explainable by the variability of Zn_{West} soil concentration. The variability of Cu_{West} explains 7 % and of Cu_{LE} almost 5 % of the variability of Cu in plant tissue (Tab. 4.7).

Mean Zn concentration ranged between 4.0 mg/kg dm (AAAc-EDTA extract) and 8.0 mg/kg dm (Westerhoff-extract). These values are higher than determined by Sillanpää (1982) with 0.87 mg/kg dm and comparable to (DTPA[3])-extractions of alluvial soil carried out by El-Fouly (1984) at the beginning of the eighties with 2-7 mg/kg dm. At those times, mean concentration of Zn in Egyptian soils was below the international average (Sillanpää, 1982).

Mean concentration of zinc in plant tissue amounts to 28.9 mg/kg dm. In field trials with *Gossypium barbadense* in Egypt, Zn concentration ranged between 2 and 122 mg/kg dm, but in the majority of cases between 20 and 40 mg/kg dm (Tab. 8.5, Appendix).

Mean copper concentration ranges between 9.4 mg/kg dm (Westerhoff-extract) and 11.4 mg/kg dm (AAAc-EDTA-extract) on the same level as analysed by Sillanpää (1982) with 8.6 mg/kg dm and by El-Fouly (1984) in alluvial soil with 5-12 mg/kg dm (DTPA-extract). According to Sillanpää (1982), in the international comparison Egyptian soils were very well supplied with Cu.

Mean concentration of copper in plant tissue was determined at 12.1 mg/kg dm. In field trials carried out in Egypt concentration of Cu in *Gossypium barbadense* ranged between 5 and 25 mg/kg dm, with a certain clustering of values between 10 and 20 mg/kg dm (Tab. 8.5, Appendix).

Mean B concentration in soils was 5.4 mg/kg dm. B in soils was not determined in 2008. In 2009, it was with 11.4 mg/kg considerable higher than in 2010 with 4.0 mg/kg dm. Mean B concentration in Beheira was with 8.0 mg/kg dm respectively 6.6 mg/kg dm 3 to 4 times more elevated that at the other sampling regions. This was most probably due to marine influence. The ocean provides boron both by the deposition of vaporised boric acid, and by infiltration of boron-containing seawater (Green Facts, 2011). The values analyzed in the present study were about 10 times higher than the concentrations determined by Sillanpää (1982), possibly due to methodical reasons. In the international comparison conducted by Sillanpää (1982), Egypt ranked for B above average level.

[3] Diethylentriaminpentaacetate

Mean concentration of B in cotton tissue was determined at 49.6 mg/kg dm. Over the years, there was no great difference in mean concentrations, and over the regions, mean concentrations increased from north to south, exhibiting mean concentrations between 44 and 47 mg/kg dm at Beheira, Sharqia and Dakahlia-Damietta, 51.7 mg/kg dm at Qalyubia and 73.7 mg/kg dm at Faiyum.

Two-way ANOVA showed a significant difference, for both, boron in soils and in plant tissue, between the sampling sites (Tab. 4.2 and Tab. 4.4).

Mean soil concentration of Mo was with 0.03 mg/kg dm lower than the mean concentration elaborated by Sillanpää (1982) with 0.11 mg/kg dm, probably due to the different extractant (ammonium oxalate-oxalic acid). 30 years ago, in the international comparison Egypt ranked at above average level, as far as Mo is concerned (Sillanpää, 1982).

Mean concentration of Mo in leaves was 1.6 mg/kg dm. They were well above the average at Beheira and Faiyum and follow the same pattern as the concentration of Mo in soils. No field trials were found dealing with Mo in *Gossypium barbadense* or *hirsutum.*

Two-way ANOVA showed a significant difference for Mo in soils between the years and for Mo in plant tissue for both, the year of sampling and the sampling regions (Tab. 4.2 and Tab. 4.4).

Both elements therefore showed elevated concentrations at Beheira governorate and low concentrations in the soils of the other regions; concentrations of leaf blades followed this pattern but there were high concentrations in tissue samples at Faiyum, too. AAAc-EDTA-extractrable boron and molybdenum in the soils examined show a strong positive correlation. Both elements exhibited positive correlations with C_{total}, $CaCO_3$, P_{CAL}, P_{Olsen}, S_{LE}, K_{CAL}, K_{LE}, Ca_{LE}, Mg_{LE}, Na and electrical conductivity, negative correlations with P_{LE}, Zn_{West}, Cu_{West} and Al_{LE} in the soil (Tab. 4.7).

B in plant tissue is positively correlated to $CaCO_3$ respectively Ca_{LE} and negatively to C_{org}, P_{LE}, Mg_{LE}, Fe_{LE} and Cu_{LE}. Mo in plant tissue revealed strong and positive correlations with C_{total}, C_{org} and $CaCO_3$, N_{total}, K_{CAL}, K_{LE} and Ca_{LE} and negative correlations to Fe_{LE} and Al_{LE}. These are indication for a competition of cations in the root zone and for the common source of sea water for B and Mo in the soils of the coastel region (Tab. 4.8).

The above examination of soil-plant relationships shows, that a range of nutrients (N, P, S, K, Ca, Mg, Bo and Mo) are elevated in the soils of the Beheira governorate, the high yielding region of the present investigation. For some of these nutrients, elevated leaf tissue concentrations were measured in plants from Beheira, too: S, K, Ca, Mg, Cu and Mo. As the available data alone do not indicate, whether soil nutrient concentrations are above plant need for one or several of the above mentioned elements, a comparison with data from literature on soil surveys and field experiments with *Gossypium hirsutum* was undertaken. Taking into account the marine influence, at least Ca, S, B and Mo may be present in Beheira soils in concentrations well above plant need which in turn may have an influence on the level of the critical value determined in plant tissue for these elements. As concluded in the previous chapter 5.3, the comparison with reference data on the critical value for Ca in *Gossypium hirsutum* allows the supposition, that the deduced critical value for this element in the present work is suitable. A lack of data on the needs of the cotton plant in general and *Gossypium barbadense* in particular indeed support the need for further research on the plant requirements for S, B, and Mo.

Besides the depletion of the soils of the low yielding regions (Sharqia, Qulyubia, Dakahlia-Damietta and Faiyum), other factors influencing yield were detected by verifying soil-plant interactions, all in relation to the water supply of the cotton fields:

First, this was the absolute amount of water available. Plant carbon concentration as indicator for water deficiencies was particularly elevated in Sharqia, Qualyubia, Dakahlia/Damietta. The yearly evaluation shows, that cotton tissue concentrations for C were especially high in 2009, possibly an indication for climatic stress.

Secondly, according to statistical analyses, salinization strongly influences the availability of nutrients and the water-uptake by plants. The latter can be deduced from more elevated values for Na and electrical conductivity in soils in 2009 in connection with the higher cotton tissue concentration in that year. Correlation analyses and regression analysis however only showed limited influence on the availability of nutrients in soil or the concentrations of nutrients in plants.

Thirdly, an oversupply of certain micronutrients and of aluminium had a statistically proven influence on the availability of plant nutrients in soil and their translocation into the cotton plant. No final answer can be given, whether these relations only take place in the upper layer of the soil, which was the only layer sampled in the present investigation or whether the presence of Fe, Mn and Al influences nutrient uptake in the whole root zone (which is indicated by correlation analysis). It is possible that a certain percentage of Fe, Mn and Al are precipitated at the soil surface, due to the elevated soil pH-level and oxidising conditions at the top layer of the soil and that the remaining part of the elements in solution is transported towards the root zone. Top-layer accumulated elements may then be transferred to the leaf surfaces. This might also be an explanation for the elevated Al-concentration of dairy products (Deeb and Gomaa, 2011), as beerseem sown as a preceding crop to cotton is used as fodder for dairy cows.

There were comparably low values for Fe, Mn and Al in soils and leaf tissue samples at Beheira. This had as consequence, that the evaluation of leaf tissue samples using critical values deduced over all sampling sites misleadingly indicated a need for these elements at Beheira governorate.

5.5 Organic and biodynamic cultivation

Production practices “organic” and “biodynamic” at Beheira governorate did not show a statistical difference in yield (see chapter 4.1). A pre-requisite for the validity of such a comparison is, that the conditions in both groups are equal. That could be proven for soil (see chapter 4.2.3) and plant parameters (see chapter 4.3.3).

5.6 Nutrient status of examined cotton fields

Apart from the nutrient concentration in the soils, other factors were identified as being an important influence for the nutrient supply of cotton plants.

One was the irrigation water: absolute water shortage and salinity both led to water deficiency stress for the cotton plants. Salinity, caused by insufficient water amounts used for irrigation, aggravated by the poor water quality of reused irrigation water, caused a competition of cations (i. e. Na^{+} and Ca^{2+}) and of anions (i. e. Cl^{-} , SO_4^{2-}, PO_4^{2-}) with plant nutrients in the root zone. The competition of Al, Fe and in some cases Mn with cations in general and other micronutrients in particular may alter the cation exchange capacity in the root zone and may have further reduced the availability of nutrients for the plant.

A second factor is the concentration of soil organic matter. Soil humus operates as slow release compound fertilizer and soil conditioner. It increases soil structure stability and water holding capacity. In the present study, the high yielding sites at Beheira governorate contained considerably more soil organic carbon than the other sites.

A third is the pH-level of the soil, as availability of a range of nutrients declines with rising pH-level due to the formation of insoluble phosphates and carbonates.

Below, the accumulated information will be used to evaluate the nutrient status for the cotton fields examined. This will be carried out, on one hand, exemplarily for individual fields, and on the other hand with respect to the distinct sampling regions Beheira W and O, Sharqia W and O, Dakahlia-Damietta, Qalyubia and Faiyum.

5.6.1 Individual fields

In Tab. 4.15, results of the analyses of cotton plant tissue from eight different farms were summarized.

In Tab. 5.2, a reassessment of the PIPPA-evaluation was undertaken with respect to the findings of the above discussion: no deficiencies were assumed for S and Fe, as these elements were present in soils in sufficient amounts or even in excess.

- The high yielding farms no. 163 and 710 at Beheira did not show strong deficits. At farm no. 163, strong concentrations of Na_{H2O} and a high value for electrical conductivity in soils did not result in high Na concentrations in plant tissues.
- This was different at farm no. 755 at Sharqia west, where a comparable result with farm no. 163 and corresponding values for Na and electrical conductivity resulted in a very low yield, a case in which water shortages might have to be blamed.
- Deficiencies for K and B at farm no. 757 at Sharqia west were not strong, whereas the critical value for Mn was undercut. While Na and electrical conductivity were only slightly elevated, the corresponding yield was below average.
- Farm no. 762 at Sharqia east was the only one for which Zn and Cu deficiencies were diagnosed.
- Farm no. 7822 at Dakahlia and farm no. 696 at Qalyubia exhibited the same wide range of deficiencies. Farm no. 7822 was the only one investigated using some mineral fertilizer and running a two-year rotation (Tab. 8.10, Appendix).
- Concerning farm no. 677, situated at Faiyum, a strong phosphorus demand was discovered. Despite quite moderate values for Na_{H2O} and electrical conductivity in the soil, plant tissue concentrations at this location were extremely high for Na.

It should, anyhow, be born in mind that besides for S, the present available data set also results in elevated critical values with respect to the micronutrients B and Mo.

Tab. 5.2: Nutritional status of Egyptian organically grown cotton from different farms assessed by PIPPA.

Farm no	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo
163						(x)		x				
710		(x)										
755		(x)						(x)				
757				(x)				x			(x)	
762					(x)				x	x		x
7822	**X**			**X**	(x)	(x)		**X**			x	**X**
696	(x)			**X**	(x)	x		x			x	x
677		x										

(x)=minor, x=moderate, **X**=strong deficiency

5.6.2 Regions

In Tab. 4.20, results of the cotton tissue analyses of the seven different sampling regions according to the evaluation methods PIPPA, DRIS and CND were summarized.

A reassessment of the PIPPA-evaluation for the seven different sampling regions was undertaken, as discussed for a choice of farms in the preceding chapter. The deficiencies diagnosed for the farms in the different sampling regions correspond to the farmwise diagnoses of chapter 5.6.1. The result can be summarized as follows:

- Strong nitrogen deficiencies were found only at the Dakahlia/Damietta governorate, where two of the few samples were from a farm not long converted to organic farming and running a two-year rotation.
- Except for Sharqia-W and Dakahlia/Damietta, phosphorus was in need in the soils of all governorates, especially in the southern part of the delta region and in Faiyum.
- Potassium deficiencies were especially severe in the central delta region but less aggravated at Faiyum.
- Despite high $CaCO_3$-concentrations in the soils of the Beheira governorate, calcium deficiencies in leaf tissue were detected in some samples from this governorate, too.
- Mg was diagnosed deficient in some samples in all governorates.
- A slight Mn deficiency was evaluated at Beheira-O and in the central part of the delta.
- Only at Sharqia-O, Zn and Cu-deficiency was indicated.
- Boron was in need in the soils of Beheira and Sharqia and Mo was indicated as strongly deficient in the central delta region.

Concerning the regional assessment, is has also to be considered, that critical values of the micronutrients B and Mo need futher affirmation.

Tab. 5.3: Nutritional status of Egyptian organically grown cotton from different regions assessed by PIPPA.

Region	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo
Beheira-W		(x)				(x)				(x)	x	
Beheira-O	(x)	(x)			(x)	(x)		(x)		(x)	x	(x)
Sharqia-W	x			X	x	(x)		(x)		(x)	x	**X**
Sharqia-O	x	(x)		**X**	x	x			(x)	x	x	**X**
Dakahlia/Da.	**X**			**X**	x	x		**X**		(x)	(x)	**X**
Qalyubia	(x)	**X**		**X**	(x)	x		(x)			(x)	**X**
Faiyum	(x)	**X**		x		x				X		(x)

(x)=minor, **x**=moderate, **X**=strong deficiency, X=very strong deficiency

5.7 Further research needs

Due to the restricted number of samples, caused by a limited organic cotton area in Egypt, high-yielding cotton farms are concentrated in one region, the governorate Beheira. Further data on *Gossypium barbadense* leaf tissue analyses are needed to verify the deduced critical values. This is especially the case where high concentrations in plant tissue, which may not be yield relevant, are a result of elevated soil concentrations. This may be the case for S, B and Mo. The deduced critical value for Cu revealed a larger yearly variation, another reason for further research.

Concerning the specific evaluation of nutrient deficiencies for *Gossypium barbadense* at different Egyptian regions, the role of irrigation water in the supply of fields with wanted (i. e. K^+, Ca^{2+}) and unwanted elements (i. e. Na^+, Mn^{2+}, Fe^{3+}, Al^{3+}, SO_4^{2-}), may be of interest.

6 Summary

An "on farm" research was carried out in three consecutive years (2008-2010), investigating production sites of organically or biodynamically certified Egyptian cotton situated in the Nile delta and Faiyum oasis. 207 data sets on the nutrient concentration of leaf tissue samples of youngest, fully differentiated main stem leaves from the top of Egyptian cotton plants (*Gossypium barbadense*) at the growth phase between “candle-stage of bud-development” and “appearance of first bolls” and corresponding soil samples were statistically analysed using SPSS (2010), version 17.0. Soil concentrations were far more heterogeneous than plant concentration, which showed a better accordance to a normal distribution. The interaction between element concentrations in soil and plant were not in every case evident. Only a few elements (K, Ca, Zn) showed marked soil / plant correlation and there were negative correlations of Fe, Al and Mg in soil to a range of nutrients in plant tissue. Thus plant data were more suitable for the deduction of specific critical values for *Gossypium barbadense* than data from soil analyses.

Plant tissue analysis data were used to deduce the equations of boundary lines according to Webb (1972) and to determine corresponding critical values for plant nutrient concentrations. On the basis of the mathematical transformation of the “Boundary Line” approach (BOLIDES), published by Heym and Schnug (1995), algorithms were programmed using Mathematica 7 (Wolfram ResearchInc., 2010), in order to obtain boundary lines and critical deficiency values for cotton leaf tissue. These critical values were compared to those obtained as mean values of analysis data of the best performing 15 % of the group, as proposed by Beaufils and Sumner (1976). Other methods to separate high yielding and low yielding subgroups were also tested (Cate and Nelson, 1971; Khiari et al., 2001a) but failed, obviously because there was no distinct correlation between the independent factor (nutrient) and the dependent factor (yield).

The equations of the boundary lines thus determined for the nutrients N, P, S, K, Ca, Mg, Fe, Mn, Zn, Cu, B, Mo as well as for C were then used to evaluate the whole data set according to PIPPA, the “Professional Interpretation Program for Plant Analysis” (Schnug, 1990). An evaluation of the same data set was executed with the systems DRIS, “Diagnosis and Recommendation Integrated System” (Beaufils, 1973; Beaufils and Sumner, 1976) in the simplified formula proposed by Walworth and Sumner (1987) and CND, the “Compositional Nutrient Diagnosis” system as developed by Parent and Dafir (1992).

The comparison of critical values, determined by use of the BOLIDES approach, with the statistical mean of the best 15 % of the population showed a higher critical value for N deduced by BOLIDES, all other values were lower than the statistical mean values. The reason for this difference was found to be inherent to the system of BOLIDES, which provides an elimination of outliers.

The evaluation of nutrient deficiencies exhibited a good consistency of the results of the three systems, despite of the different approaches. PIPPA as univariate evaluation system, using the nutrient response curve determined by BOLIDES, detected a lower number of deficiencies, but assessed these deficiencies more seriously. DRIS as bivariate system sets the actual nutrient concentration to be evaluated in relation to all other plant nutrients analysed and to their corresponding critical values. The relation between plant tissue concentration and yield is linear. This resulted in an increase of the number of elements analysed as deficient, while the assessments were in tendency more moderate than with BOLIDES. CND as trivariate system additionally sets the

nutrients in relation to their geometric means and deduces log-ratios, which resulted in an even further levelling of index values.

As high-yielding plots were gathered in one area, elevated leaf tissue concentrations of nutrients, which coincidentally occurred at this sampling site without possessing a physiological yield effect, were considered for the deduction of critical values. This was presumably the case for S, B and Mo. The values for these nutrients therefore need further affirmation, especially as almost no reference data on the concentration of these nutrients in cotton plants are available. It can be assumed, that with an increasing number of disposable samples from different high yielding sites, the problem could be reduced.

Most of the yearly deduced critical values showed continuity over the years. This indicates, that the values may be valid for future times. Cu as an exemption showed a large divergence over the years and thus needs reevaluation.

Regional critical values, deduced for the high yielding and a low yielding region, very clearly showed the different production potential between regions. For the low yielding region, they indicate the restrictions for obtaining a higher yield.

Zusammenfassung

Auf Erzeugerbetrieben von biologisch bzw. biodynamisch zertifizierter Baumwolle in Ägypten fand in drei aufeinander folgenden Jahren (2008-2010) eine Praxisuntersuchung statt. Die landwirtschaftlichen Betriebe lagen im Nil-Delta und der Oase Faiyum. 207 Datensätze mit den Nährstoffkonzentrationen von Blattproben der jüngsten voll ausgebildeten oberen Blätter des Hauptsprosses von Ägyptischen Mako-Baumwollpflanzen (*Gossypium barbadense*), die innerhalb des Entwicklungabschnitts “Knospe im Kerzenstadium“ bis „Erscheinen der ersten Baumwollkapseln“ gesammelt worden waren, sowie die entsprechenden Bodenproben wurden mittels SPSS (2010), Version 17.0 statistisch ausgewertet: demnach waren die Konzentrationen in den Bodenproben weitaus heterogener verteilt als in den Pflanzenproben, deren Nährstoffkonzentrationen in einem höherem Maß normal verteilt waren. Nur wenige Nährelemente (K, Ca, Zn) wiesen eine ausgeprägte Korrelation Boden / Pflanze auf. Die Bodenparameter Fe, Al und Mg waren zu einer Reihe von Nährstoffgehalten im Pflanzengewebe negativ korreliert. Insgesamt zeigten sich daher die Pflanzendaten als besser geeignet als die Bodendaten, Ertrags-Grenzwerte für *Gossypium barbadense* abzuleiten.

Daten der Pflanzengewebsanalysen wurden verwendet, um Gleichungen der Grenzlinien nach Webb (1972) abzuleiten und die dazugehörigen Grenzwerte für Pflanzennährstoffe zu bestimmen. Auf Basis der mathematischen Darstellung des Grenzlinien-Ansatzes (BOLIDES) durch Heym and Schnug (1995) wurden unter Zuhilfenahme von Mathematica 7 (Wolfram Research Inc., 2010) Algorithmen programmiert, um Grenzlinien und Ertrags-Grenzwerte für das Blattgewebe von Baumwolle zu berechnen. Die so ermittelten Grenzwerte wurden mit Analysedaten-Durchschnittswerten der Hochertragsgruppe verglichen, die sich aus den Betrieben mit den 15 % höchsten Erträgen rekrutierten, ein Ansatz, der von Beaufils und Sumner 1976 vorgeschlagen wurde. Es wurden auch andere Methoden überprüft, um die Hochertragsgruppe von der Gesamtgruppe zu separieren (Cate und Nelson, 1971; Khiari et al., 2001a). Diese Methoden führten zu keinem sinnvollen Ergebnis, offensichtlich, weil es keine ausgeprägte Korrelation zwischen dem unabhängigen Faktor (Nährstoffkonzentration) und dem abhängigen Faktor (Ertrag) gab.

Die Gleichungen der Grenzlinien wurden für die Nährstoffe N, P, S, K, Ca, Mg, Fe, Mn, Zn, Cu, B, Mo wie auch für C bestimmt und im Anschluss genutzt, um den gesamten Datensatz gemäß den Vorgaben von PIPPA, dem “Professionellen Interpretationsprogramm für die Pflanzenanalyse” (Schnug, 1990) zu evaluieren. Die Evaluierung des gesamten Datensatzes wurde auch mit dem System DRIS, “Integriertes Diagnose- und Beratungssystem” (Beaufils, 1973; Beaufils und Sumner, 1976) in der vereinfachten Fassung, wie von Walworth und Sumner (1987) vorgeschlagen, durchgeführt. Eine Evaluierung erfolgte außerdem mit Hilfe des Systems CND, dem “Kombinatorischen Nährstoffdiagnose”-System von Parent und Dafir (1992).

Der Vergleich der Ertrags-Grenzwerte aus dem Ansatz von BOLIDES mit denen, die sich als Durchschnittswerte der Analysen der Hochertragsgruppe der 15 % Besten ergaben, zeigte für N einen höheren kritischen Gehalt nach dem BOLIDES-Ansatz, für alle anderen Nährelemente waren die Ertrags-Grenzwerte niedriger als die statistischen Durchschnittswerte. Der Grund für diesen Unterschied ist in Bezug auf BOLIDES systemimmanent, da im Zuge der Herleitung der Formeln für die Grenzlinien eine Elimination von Ausreißern vorgenommen wird.

Die Evaluierung der Nährstoffmängel durch die drei Systeme PIPPA, DRIS und CDN zeigte eine gute Übereinstimmung der Ergebnisse, trotz der Verschiedenheit der Ansätze. PIPPA, welches als

eindimensionales Evaluierungssystem die durch BOLIDES ermittelte Grenzlinienkurve nutzt, errechnet eine niedrigere Anzahl von Nährstoffdefizite, diese Defizite werden jedoch als ersthafter eingestuft als durch die anderen beiden untersuchten Systeme. DRIS als zweidimensionales System setzt die zu evaluierende Nährstoffkonzentration in ein Verhältnis zu allen anderen analysierten Pflanzennährstoffen und den dazugehörigen kritischen Nährstoffgehalten. Das Verhältnis zwischen Pflanzengewebskonzentration und Ertrag ist linear. Dies führt zu einer Zunahme der Anzahl an Elementen, die als defizit analysiert werden, während die Bewertung tendenziell moderater als mittels BOLIDES ausfällt. In CND als dreidimensionalem System werden die Nährstoffgehalte zu ihren geometrischen Mittelwerten ins Verhältnis gesetzt und es werden daraus Logarithmen abgeleitet, ein Vorgehen, welches zu einer noch stärkeren Nivellierung der Indexwerte führt.

Da die Hochertragsflächen in einer Region gehäuft anzutreffen waren zeigte sich, dass erhöhte Pflanzennährstoffgehalte, welche zufällig in derselben Region auftraten ohne tatsächlich einen physiologischen Effekt zu haben, die Ableitung von Ertrags-Grenzwerten beeinflussen. Dies war möglicherweise der Fall in Bezug auf S, B und Mo. Die ermittelten Ertrags-Grenzwerte für diese Nährstoffe bedürfen deshalb einer weiteren Bestätigung, insbesondere auch deshalb, weil kaum Literaturangaben zu den Ertrags-Grenzwerten dieser Elemente in Baumwollpflanzen, sowohl in für *Gossypium barbadense* als auch für *Gossypium hirsutum*, vorliegen. Es kann davon ausgegangen werden, dass mit einer zunehmenden Anzahl an verfügbaren Proben aus unterschiedlichen Hochertragsstandorten das Problem vermindert werden kann.

Die meisten jährlich abgeleiteten Ertrags-Grenzwerte zeigten im Verlauf der Jahre Kontinuität, was darauf hindeutet, dass diese Werte auch künftig Bestand haben werden. Kupfer bildete eine Ausnahme und zeigte über die Jahre ausgeprägt unterschiedliche Werte. Dieser Wert bedarf daher einer weiteren Evaluierung.

Regionale Ertrags-Grenzwerte der Hochertrags- und Niedrigertragsstandorte zeigten sehr deutlich das unterschiedliche Ertragspotenzial der Regionen. In Bezug auf einen Standort mit niedrigem Ertrag zeigen sie die Begrenzungen für eine Ertragssteigerung auf.

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8 Appendix

Tab. 8.1: Essential plant nutrients and their function in cotton (Stevens et al., 2002; Stewart, et al., 2003; Hodges and Constable, 2010).

Element	**Relative concen-tration in plant*)**	**Phloem mobility**	**General functions in plant**	**Metabolic responses to deficiency in cotton**	**Growth responses to deficiency in cotton**
N	**100**	**yes**	water and solution uptake, protein metabolism, photosynth esis, carbon partitioning, enzyme and plant hormonal activities	reduced growth rate of leaves (enzyme proteins of chloroplasts contain 75 % of organic N in leaves), water potential, accumulation of assimilates (i. e. starch)	increased root:shoot ratio; reduced vegetative branching, stem diameter, plant height, main stem node number, leaf number, fruiting branch development and total plant dry weight, square and boll shedding, seeds per boll, fiber length, lint weight, seed weight
P	**6**	**yes**	nucleic acids, ATP, photosynth esis, cell division	accumulation of non-phosphorylated sugars and starches and of anthocyanins; reduced hydraulic conductivity in the roots (esp. during the day) and transport of assimilates; insufficient turgor in leaves	reduced leaf expansion rate, leaf area and flowering; delayed initation of squares and boll maturation; decreased boll set; early senescence
K	**25.5**	**yes**	catalyst, ion transport, enzyme systems, reduces incidence and severity of wilt diseases, increases water use efficiency	accumulation of soluble sugars and simple carbohydrates in response to osmotic needs to maintain turgor; reduced photosynthesis and transport of assimilates; ATP-accumulation; accumulation of soluble N-compounds due to inhibition on protein-sythesis; increase of enzyme activity of hydroxylases and oxidases → accumulation of superoxide radicals → chlorosis → destruction of chloroplasts; slower stomatal response to water stress; underdeveloped epidermal cuticule; impaired lignifications of vascular bundles → increased lodging potential; low leaf area and dry matter accumulation in leaves; reduced leaf expansion rate, meristem growth, main stem nodes, stem height, stem weight and total plant dry weight; increased root:shoot dry weight relation	(reproductive tissue, especially burr and fiber, consists 65-70 % of total K) → premature shedding; decreased boll number and boll size; reduced lint yield, seed-yield, oil-concentration in seeds, fiber length, uniformity, micronaire and maturity
S	**3**	**(yes)**	amino acids, constituent of biological membranes	deficiency: decrease in total sugar and protein-N; increase in NO_3, soluble organic N and non-S containing amino acids; shortage of cysteine and methionine → decreased chlorophyll content → chlorosis; reduced synthesis of glutathione → reduced ability to detoxify oxidants and heavy metals; sulfolipids → constituent of biological membranes (i. e. thylakoid membrane of chloroplasts), → positively correlated to salt tolerance; component of enzymes;	reduced leaf area, root hydraulic conductivity, stomata aperture, net photosynthesis rate; decreased shoot:root ratio; N-deficient plants develop S deficiency symptoms first on older leaves, N-sufficient plants on youngest leaves
Ca	**12.5**	**(yes)**	cell wall component	decreased cell division; reduced cell wall strengthening, destabilisation of membrane and cell wall structures (by replacement of Ca through other ions); leakage of cells, irregularities in cell shape, increasing activity of polygalacturonase → degradation of pectates in cell walls, reduced resistance to fungal and bacterial infections	poorly developed root system → reduced water uptake, low lint yields, poor fruiting, excessive large vegetative plants

Element	Relative concen-tration in plant*)	Phloem mobility	General functions in plant	Metabolic responses to deficiency in cotton	Growth responses to deficiency in cotton
Mg	8	yes	central ion of chloro-phyll mole-cule	reduced size, structure and function of chloroplast, including electron transfer in photosystem II; reduced phloem loading of sucrose in Mg-deficient leaves due to inactive ATPase → reduced export of photosynthates → feedback to RuBP carboxylase/oxygenase synthesis towards oxygen producing reactions → superoxide radicals, H_2O_2 → chlorosis and necrosis; prevention of aggregation of ribosome subunits → reduced protein synthesis → increase of non-protein-N	decrease of plant dry weight and branching, but little influence on plant height, leaf number and leaf area; increase of S, K and Cu, decrease of P; increased shoot:root ratio
Fe	0.2	no	chlorophyll synthesis	major effect on light-harvesting and electron transport system of photosynthesis; fewer thylakoid membranes per chloroplast → fewer electron carriers, chlorophyll, ferrodoxin and carotene → fewer photochemical units per leaf area (reversible); reduced activity of Ru5Pkinase → affects regeneration of RuBP; reduced activity of catalase → cell senescence; reduced activity of peroxidase → accumulation of phenolics; reduces activity of nitrate reductase → affects ethylene synthesis; excess cation uptake → increase of reducing capacity and net excretion of protons can mobilize Fe in root zone and increase uptake	severe deficiency inhibits cell division and reduces cell growth, especially at apical meristem; inhibited root elongation and stimulated root hair production; reduced yield; reduces micro-naire and fiber length
Mn	0.1	no	known in ~35 en-zymes as cofactor or activator	reduced supply of nonstructural carbohydrates → reduced root growth; decrease of photosynthetic oxygen evolution and therefore assimilates and high energy phosphates (reversible); severe deficiency: decreased chlorophyll content, changes in structure of thylakoids (non-reversible), caused by inhibition of biosynthesis of lipids and carotenes; secondary metabolites in the shikimic acid pathway (i. e. aromatic acids, important in the plant defense system and for lignin synthesis) depend on Mn as cofactor → decrease in lignin-content; high levels of IAAoxidase	many non-vacuoled leaf cells; reduced growth rate of roots, susceptible to wilt diseases; delayed flowering; lower yield due to reduced carbohydrate supply
Zn	0.03	no	activates enzymes	deficiency: sugar and starch accumulation in leaves; protein synthesis and protein content is decreased while amino acids accumulate; decreased DNA and RNA-concentration; structure of ribosomes is affected; sites of protein synthesis (i. e. pollen tube, shoot meristem) are particularly affected; enhanced de-gradation of existing proteins; decreased degree of unsaturated acids in membrane lipids; increase of superoxide generating oxidase enzymes and decrease of activity of superoxide dismutase → higher level of toxic radicals → increased plasma membrane permeability → increased leakage of low molecular weight solutes, → chlorosis and necrosis; enhanced P-uptake → induced P-toxicity; enhanced B-uptake → induced B-toxicity	young developing leaves are smaller than normal but thicker, due to a thickened palisade mesophyll; retarded stem elongation; enlarged root tips; crooked root hairs; increased root exudates; cease of growth; shedding of buds; abortive flowers; delayed maturity; low fiber quality
Cu	0.01	(yes)	component of enzymes	decrease of activity of Cu-containing enzymes; decrease of plastocyanin→ electron transport chain of PSI is affected → reduced assimilation of soluble carbohydrates; reduced CO_2-fixation; reduction of CuZn-superoxide dismutase → reduced detoxification potentials for superoxides → photooxidation of mem-branes of chloroplasts; impaired lignification of cell walls →, characteristic distortion of young leaves, the bending and twisting of stems and enhanced lodging; reduced disease resistance; delayed flowering, delayed or poor fruit set	reduced yield due to decreased photosynthate production, reduced flowering and impaired pollination; reproductive growth is more affected than vegetative tissue, high micronaire index

Element	Relative concentration in plant*)	Phloem mobility	General functions in plant	Metabolic responses to deficiency in cotton	Growth responses to deficiency in cotton
B	**0.2**	**no**	cell wall component	reduced cell division and cell elongation; thickening of primary cell walls; shift in metabolism towards pentose phosphate cycle with enhanced phenol production and -accumulation → increased activity of polyphenol oxidase → superoxide radicals → damaging membranes; →inhibition of IAAoxidase-activity; reduction of plasma membrane bound H^+ pumping ATPase activity → reduced uptake of glucose	Inhibited meristem growth which may die and give way to many lateral branches with short internodes; inhibition of root elongation; slimy and thickened roots with necrotic tips; rupturing at the base of squares, flowers and early bolls; excessive flow of nectarines, squares and young bolls desiccate; incomplete fertilization of seeds and deformed bolls (hook-bill shape); discolored lint at the base; impaired pollen tube lengthening by callose and phytoalexins; amount and composition in the nectar is changed; decrease in fiber length and micronaire
Mo	**0.0001**	**(yes)**	involved in N-fixation	limited ability to convert NO_3-N to reduced forms (Mo is cofactor of nitrate-reductase); diversion of catalytic property of nitrate-reductase to other substrates, i. e. peroxidation of membrane lipids; accumulation of amino and organic acids	rapid growth reduction, abnormal boll development, boll do not open normally, reduced micronaire
Cl	**0.3**		photosynthesis reactions		
Ni	**0.001**		component of enzymes		

*) Relative amounts of mineral elements compared to nitrogen in dry shoot tissue.

Tab. 8.2: Nutrient deficiency symptoms of cotton (*Gossypium hirsutum*), (Bergmann, 1993; Stewart et al., 2010; Rutec, 2010; Hodges and Constable, 2010).

Ele-ment	Deficiency symptoms
N	pale, yellowish green foliage, evenly distributed over the leaves; older leaves dry up and shed prematurely; anthocyanins are sometimes produces at the lower section of the plant; stunted growth; fruiting branches fail to develop; abortion or shedding of terminal buds; premature boll drop
P	dwarf growth; dark foliage, older leaves become chlorotic around the margins, nedeecrosis develops and the leaf drops; number and length of fruiting branches is reduced; flower production is reduced and delayed; less bolls are set; delayed ripening; usually symptoms are not strongly expressed and occur late in plant development
K	dwarf growth; yellowish white mottling in interveinal areas of older leaves; tip and margin of leaves scorch, curl downwards and shrivel; whole leaves turn reddish brown, die and shed prematurely; petioles can develop necrotic lesions; main stem and branches become dry and wither; dwarfed immature bolls; plants are more susceptible to drought stress and wilt diseases
S	short, slender-stemmed plants with small, pale green to yellow leaves; younger leaves are first affected; general plant growth is stunted and branching is reduced; in severe cases, pale brown necrotic lesions develop in tissue adjacent to the margins of leaves and margins become wavy and cupped upwards; fewer and smaller balls are produced
Ca	stunted, bushy growth, with thin stems and dark green leaves; deficiency symptoms occur first on young leaves; deficiency affects root growth and development, root tips turn brown and begin to die; plants appear wilted, petioles hanging down the stem; additional nutrient deficiency symptoms may occur; shortened internodes near the top of the plant, buds turn brown and die
Mg	pale green to yellow coloring, followed by interveinal chlorosis, frequently accompanied by purplish red colora-tions, veins remain at the beginning unaffected and remain green; resembles normal aging, appears first in older leaves; premature shedding
Fe	deficiency symptoms occur first on new developing tissues; leaves turn pale green, followed by interveinal chlo-rosis, each new leaf appears smaller and more bleached than the last, under severe cases leaves may become white and devoid of chlorophyll, leaf margins may curl upwards, stems become thinner
Mn	deficiency symptoms occur first on new developing tissue; leaves are small and turn pale green; faint interveinal yellow-red chlorosis with dark veins; crinkle leaf with margins cupping downwards and roll in; small brown necrotic lesions; plants can be stunted with short thick stems
Zn	"little-leaf" symptom in the upper part of the plants: abnormally small, thickened and brittle leaves with inter-veinal chlorosis; reduced internode elongation; older leaves can develop dark brown interveinal necrotic spots; anthocyanin accumulation in petioles may occur; bushy, rosetted appearance; fruiting and ripening, as well as ball opening is delayed
Cu	severe stunting, dull, yellow chlorosis on older leaves, leaving veins and adjacent tissue dark green, plant has a limp, wilted appearance with leaves held almost vertical, symptom development is rare but confirmed for soils with high organic matter content
B	petioles of younger leaves are short and thickened while internode elongation is also stunted; dwarf, bushy, broom-like appearance; may appear both in new and old growth alike; dark rings on leaf petioles; with pro-gressing season leaves might become deformed, with increased hair-growth and resembling leather; shortened flower corollas with ends of petals folded inwards; reduced number of flowers; anthers are necrotic, premature shedding, hidden hunger might show few characteristic symptoms
Mo	symptoms similar to N-deficiency interveinal chlorosis, appear first on older leaves, greasy leaf surface, thicken-ing of leaves, leaves become cupped, develop necrotic spots and leaf margins at older leaves; stunted plant appearance, pale withered leaves, deformation of balls

Tab. 8.3: Sources and general set ups for the deduction critical deficiency values and sufficiency ranges for cotton (*Gossypium barbadense* and *hirsutum*).

Year	Reference	Variety	Country	Kind of experiment[1)]	Growth stage	Plant part[2)]	Method: deduction critical values
1959	Samuels et al.	-	Puerto Rico	-	45 days after flowering	YFDLMSt	-
1961	Malavolta and Gomes	-	Brazil	-	early/mid-bloom	YFDLMSt	-
1961	Peterson and Purvis	-	USA	R-sand	-	leaves	-
1964	Jordan	-	southern US		midseason	leaves and petioles	-
1967	Kallinis and Kouskoleka	Cocker		R-ns	-	leaves	-
1967	Kallinis and Vretta-Kouskoleka	-	Greece	R-ns	5 months	leaf blades	-
1968	Kouskoleka and Kallinis	Cocker		R-ns	-	young leaves	-
				R-ns		mature leaves	-
1968	Vretta-Kouskoleka and Kallinis		Greece	R-ns	2 months	young leaf blades	-
				R-ns		old leaf blades	-
1969	Oertli and Roth	-	USA	R-ns	63 days after transplantation	whole shoot	-
1970	Gheesling and Perkins	-	USA	R-sand	105 days	leaf-blade	-
1971	Anderson et al.	-	Georgia	**oF** + Scd	-	upper mature leaves (three leaves/plant)	-
1971	Murphy and Lancaster	-	USA	**Fe**	-	3rd and 4th mainstem leaf from top	-
1972	Sabbe et al.	-	Arcansas	**oF** + Scd	-	most recently fully developed leaf (1 leaf/plant)	-
1972	Duel and Swoboda	-	USA	R-soil	42 days after seeding	whole shoot	-
1974	Ohki	Cocker 310	Georgia, US	R-ns	36 days after transplanting into nutrient solution	blade 3	dm-production/increasing Zn-concentrations and B-concentrations; graphical (curve)
1974	Jones	-	Georgia	Scd	early flowering	YMLB	
1975	Ohki	Cocker 310	Georgia, US	R-ns	38 days	blade 3	dm-production/increasing Zn-leaf-concentrations; graphical (curve), CV = 90 % of max yield
1976	Ohki	-	Georgia, US	R-ns	43 days	blade 4	photosynthesis, respiration carbonic anhydrase activity chlorophyll-concentration/increasing Zn-leaf-

Year	Reference	Variety	Country	Kind of experiment[1)]	Growth stage	Plant part[2)]	Method: deduction critical values
							concentrations; graphical (curve), CV = 90 % of max yield
1981	Lombin and Mustafa	-	Nigeria	**Fe**	flowering	YMLB	-
1981	Foy et al.	65 genotypes	USA	R-soil	33 days	young mature leaves	-
1984	Cope	-	USA	**Fe**, 6 different sites	early flowering	YMLB	
1985	El-Gharably and Bussler	*(G. herbaceum)* Etawa	Germany	R-ns	40 days after transplanting	youngest mature leaf blades	-
1986	Smith and Roncadori	Stoneville 213	USA	R-soil	60 days	whole shoot	-
1987	Chapman. 1973. Bergmann and Neubert 1976. Finck 1979 (compiled in: Fawzi et al)	-	-		first square	YFMLMSt	-
1987	Sedberry et al.	-	Louisiana, US	-	early boll (mid-bloom)	YFDLMSt	-
1987	Soomro and Waring	Deltapine 61	Australia	R-soil	55 days	whole shoot	-
1987	Malavolta et al.	-	Brazil	**Fe**	-	leaves	
1987	Cakmak and Marschner	Deltapine 15/22		R-ns	23 day after transplanting	middle leaves	-
1989	Jones	-	-	**Fe**-Scd	1st bloom	YFDLMSt	-
1990	Hibberd et al.	Deltapine 16	Australia	R-soil	42 days	whole shoot	
1991	Kennedy and Jones	(*G.barbadense, G.hirsutum*)	USA	R-ns	21 days after transplanting	youngest three leaves	peroxidase-activity in leaves
1992	Bergmann. W.	-	-	Lit	1st bloom to boll development	YML	-
1992	Wood et al.	-	-	-	1st pin-head square 1st flower (early bloom) mid-bloom	YFDLMSt	-
1992, 1991, 1983	Bergmann et al.	-	-	Lit	1st flowering to boll developement	YFDLMSt	-
1994	Pettiet	-	Missisippi, US	**oF**	5th week after floweirng	leaf-blade	comparison visual deficiency symptoms/leaf-analysis, 1st-7th week after flowering
1994	Weir and Cresswell	-	Australia	Fe-Lit(?)	vegetation to flowering	YFDLMSt	-
1994	Heithold	DES 119/24-8/24-8 okra leaf, Deltapine 20/5415	USA	**Fe**	40 days after seeding 60 days after seeding 102 days after seeding	YMLB	-
1995	Reeves and Mullins	Deltapine 50	USA	**oF** experiments	early flowering	YMLB	
1996	Mills and Jones	-	-	**oF**	first sqares to initial	vegetative stems	-

Year	Reference	Variety	Country	Kind of experiment[1)]	Growth stage	Plant part[2)]	Method: deduction critical values
					bloom full bloom		
1997	Mitchell and Baker	-	North Carolina, US	Scd	early bloom late bloom	YFDLMSt	-
1999	Bednarz and Oosterhuis	Deltapine 20	Georgia, US	R-pot culture	27-40 days after planting	3rd mainstem leaf from top	
2000	Mitchell and Baker	-	North Carolina, US	Scd	early bloom late bloom	YMLB	-
2000	Reddy et al.	DP NuCOTN 33B	Missisippi, US	R-pot culture, controlled conditions, natural solar radiation	early bloom	recently expanded topmost leaves	comparison visual deficiency symptoms/leaf-analysis up from first square
2002	Raschid and Rafique	CIM-240	Punjab, Pakistan	**oF** experiments	early bloom	YMLB	linear regression
2002	Zhao and Oosterhuis	Suregrow	Arcansas, US	R-growth chamber study	squaring and fruiting	fully expanded main stem leaf blades	decrease of CO2-exchange-rate and assimilate-transport from leaves to fruit
2003	Bell et al.	-	Lousiana, Arcansas, Alabama and Missisippi, US	**Fe**	1^{st} pin-head square early bloom mid-bloom cut-out	RML	Cate and Nelson, modified by (1993) Beverly
2005	Dagbenonbakin	STAM 18 A	Benin	**oF**	1^{st} bloom or appearing of first squares	YFMLMSt	low yielding sub-population: mean and interval of confidence
2009	N.N.	-	North Carolina, US	Scd	early bloom bloom fruit	YMLB	-

[1)]Lit=data compiled from literature or other resources; oF=on farm experiment; Fe=field experiment, R=experimental research; ns=nutrient solution, Scd=survey on commercial data sets;
[2)]youngest mature leaf blades=YMLB, youngest mature leaves=YML, youngest fully mature leaves on main stem=YFMLMSt, youngest, fully developed leaf on the main stem=YFDLMSt, recently matured leaves=RML;

Tab. 8.4: Critical deficiency values and sufficiency ranges for cotton leaves (*Gossypium hirsutum*).

Year	Reference	Growth stage	N	P	K	S	Ca	Mg	Mn	Fe	B	Cu	Zn	Mo	Al	Na	Cl	As
			(g/kg dm)						(g/kg dm)									
1959	Samuels et al.	45 days after flowering	50															
1961	Malavolta and Gomes	early/mid-bloom	38.5															
1961	Peterson and Purvis	-												0.75				
1964	Jordan	midseason				2												
1967	Kallinis and Kouskoleka													2.4				
1967	Kallinis and Vretta-Kouskoleka	5 months												1.5(1.9-2.4)				
1968	Kouskoleka and Kallinis	(young leaves)								85-112								
		(mature leaves)								57-88								
1968	Vretta-Kouskoleka and Kallinis	2 months (young leaf blades)								85-112								
		2 months (old leaf blades)								57-88								
1969	Oertli and Roth	63 days after transplantation									80-146							
1970	Gheesling and Perkins	105 days						2(4.0-6.9)	15									
1971	Anderson et al.		37.5-45	3-5	20-30		22.5-30	5-9	50-350	50-250	20-60	8-20	20-60					
1971	Murphy and Lancaster	-									15							
1972	Sabbe et al.		30-43	3-6.5	9-19.5		19-35	3-7.5	30-300	30-300	20		20-100					
1972	Duel and Swoboda	42 days after seeding																0.25-2.9
1974	Ohki	36 days after transplanting into nutrient solution							10(11-247)									
1974	Jones	early flowering	37.5-45.0	3-5	20-30		22.5-30	5-9	50-350	50-250	20-60	5-25			<200			
1975	Ohki	38 days											11-200					

Year	Reference	Growth stage	N	P	K	S	Ca	Mg	Mn	Fe	B	Cu	Zn	Mo	Al	Na	Cl	As
			(g/kg dm)						(g/kg dm)									
1976	Ohki	43 days											13-14(17-48)					
1981	Lombin and Mustafa	flowering			18.4													
1981	Foy et al.	33 days							49-57									
1984	Cope	early flowering	35-46	2.6-2.8	9-12.4													
1985	El-Gharably and Bussler	40 days after transplanting									61-75							
1986	Smith and Roncadori	60 days							128-337									
1987	Chapman. 1973. Bergmann and Neubert 1976. Finck 1979 (compiled in: Fawzi et al)	first square	45	2	20-60				50-350	80-300		11-20	20-60					
1987	Sedberry et al.	early boll (mid-bloom)	28.0															
1987	Soomro and Waring	55 days	21.3-24.7															
1987	Malavolta et al.	-				4												
1987	Cakmak and Marschner	23 day after transplanting											41-56					
1989	Jones	1st bloom	33	2.5	15	2	20	3	25		20	4	15	0.5				
1990	Hibberd et al.	42 days	30															
1991	Kennedy and Jones	21 days after transplanting							200-270									
1992	Bergmann. W.	first bloom to boll development	30-50	3-5	17-35		6.0-15	3.5-8					25-80					
1992	Wood et al.	1st pin-head square	58															
1992. 1991. 1983		first flower (early bloom)	54															
1992		mid-bloom	40															
1992	Bergmann et al.	first flowering to boll developement							25(25-350)		20-80	8-20		0.6-2				
1994	Pettiet	5th week after floweirng			15.1													
1994	Weir and Cresswell	vegetation to flowering	30 (30-	2.1(2.1-2.3)	13(15-30)		22-38	2.9(3-9)	15-20(25		16-19(20-	5-30				2-3.5	5-15	

Year	Reference	Growth stage	N	P	K	S	Ca	Mg	Mn	Fe	B	Cu	Zn	Mo	Al	Na	Cl	As
			(g/kg dm)						(g/kg dm)									
			35)						-500)		100)							
1994	Heithold	40 days after seeding									43-46							
		60 days after seeding									34-39							
		102 days after seeding									54-73							
1995	Reeves and Mullins	early flowering			14(14-19)													
1996	Mills and Jones	first sqares to initial bloom	35-45	3-5	15-30	2.5-8	20-30	3-9	25-350	50-250	20-60	5-25	20-200					
		full bloom	0-43	2.5-4.5	9-20		22-35	3-8		40-300	20-60	5-25	20-100					
1997	Mitchell and Baker	early bloom	30															
		late bloom	30															
1999	Bednarz and Oosterhuis	27-40 days after planting			9.5													
2000	Mitchell and Baker	early bloom	30-45	2-6.5	15-30		20-35	3-9	25-350	50-250	20-80	5-25	20-200					
		late bloom	30-45	1.5-6	7.5-25		20-40	3-9	10-400	50-300	15-200		50-300					
2000	Reddy et al.	early bloom			30													
2002	Raschid and Rafique	early bloom									53(33-65)							
2002	Zhao and Oosterhuis	sqaring and fruiting									17-20(20-80)							
2003	Bell et al.	first pin-head sqare	54															
		early bloom	43															
		mid-bloom	41															
		cut-out	38															
2005	Dagbenonbakin	first bloom or appearing of first squares	25.4	3	15.8	2.1	17.2	2.7					21					
2005		first bloom or appearing of first squares	28	2.9	16.4	2.2	17	2.7					18.4					
2009	N.N.	early bloom	30-45	2-6.5	15-30	2.5-10	12.5-30	2.5-5	20-350	50-250	20-60	5-25	20-40					
		bloom			12-25													
		fruit			7.7-25													

Tab. 8.5: Field experiments determining the nutrients status of *Gossypium barbadense* and *hirsutum*.

Year	Reference	Species[1]	Variety	Country	Growth stage	Plant part[2]	Kind of experiment[3]	Fertilizer treatment	N	P	K	Ca	Mg	Mn	Fe	B	Cu	Zn
									(g/kg dm)					(mg/kg dm)				
1987	Fawzi et al.	**Gb**		Egypt, Dakahlia		YFMLMSt	oF	n. d.	33.3 (23.4-43)	3.4 (1.7-6)	21.3 (14-30)			96(55-115)	823(370-983)		12 (5-15)	44(18-47)
				Egypt, Minia					32.1 (26-41)	3 (3-4)	33.8 (20-50)			73(40-98)	504(131-1051)		14(7-18)	45(21-122)
1992	Mullins and Burmester	Gh	Deltapine 90, Stoneville 825, Cocker 315, Paymaster 145	Alabama, US	15 days after emergence, 2-week intervals	leaves	Fe	n. d.				22-39	4-10					
1993	Mullins and Burmester	Gh	Deltapine 90, Stoneville 825, Cocker 315, Paymaster 145	Alabama, US	50 days after planting	all leaves of a plant	Fe	no micronutrients added						100	250		4	25
					75 days after planting									130	200		3.7	20
1996	Unruh and Silvertooth	Gh	Deltapine 90	Arizona	mean HUAP	leaf		3 x 52 kg/ha in-season per year, no N, P (2 sites, 3 years)	33	2.8	28							
						stem			8.6	1.4	23							
						bur			26	4.8								
					max HUAP	leaf			21	1.9	24							
						stem			5.8	0.88	14							
						bur			17	2.2	n. d.							
		Gb	S-6		mean HUAP	**leaf**			**34**	**2.1**	**28**							
						stem			9.2	1.4	23							
						bur			32	4.8								
					max HUAP	**leaf**			**23**	**2.3**	**24**							
						stem			5.1	0.86	14							
						bur			21	3.4	n. d.							
1997	El-Fouly et al.	**Gb**	local	Egypt, Kafr El-Sheikh	first square	YFMLMSt	oF	n. d.	-	**2.9(1.9-5.5)**	**21.7(13-35)**			**75(34-130)**			**14.1(7-19)**	**22.5(13-30)**
				Egypt,Beni-Swef					27(17-40)	**2.4(0.7-3.9)**	**20(12-29)**			**50(15-99)**	**162(71-240)**		**6(2-15)**	**15(2-33)**
1997	**El-Sayed et**	**Gb**	**local**	**Egypt, 14**	**10 days**	**leaves**	**oF**	**control (150-220**	**34**	**3.5**	**18**			**27**	**132**		**8**	**20**

Year	Reference	Species[1)]	Variety	Country	Growth stage	Plant part[2)]	Kind of experiment[3)]	Fertilizer treatment	N	P	K	Ca	Mg	Mn	Fe	B	Cu	Zn
									(g/kg dm)					(mg/kg dm)				
	al.			Governo-rates	after 2nd micron-trient spray (boll forma-tion)			kg/ha N, 16 kg/ha P)										
								+ 47,3 K/ha	35.5	3.7	19.4			35	146		8	23
								+ 126 Zn g/ha, + 84 g Mn/ha, +42 g Fe/ha (EDTA-chelated)	37.1	3.7	20.0			41	187		11	28
								+ 47,3 K/ha, + 126 Zn g/ha, + 84 g Mn/ha, +42 g Fe/ha (EDTA-chelated)	39.5	4	24			47	183		11	32
2002	Nofal et al.	Gb	GIZA 89	Gharbia	115 DAS	YFMLMSt	Fe	control (133 kg/ha N, 23.6 kg/ha P, 47.4 kg/ha K)	42-43	2.5-2.7	2-5		3.3-5.2	54-79	208-274		7-12	21-39
								+ Fe (3 g/l)	29-38	2.8	9		4.9-6.3	41-88	278-281		9-19	29-31
								+ Mn (3 g/l)	29-40	2.1-3.2	7-10		5.7-5.9	62-95	208-318		11-18	35-38
								+ Zn (3 g/l)	26-42	2.2-2.9	6-13		4.4-5.6	61-82	215-411		12-18	29-41
								+ Fe (3 g/l) + Mn (3 g/l)	29-41	2.6-3.1	8-9		6-6.4	71-135	226-389		12-17	38-42
								+ Fe (3 g/l) + Zn (3 g/l)	31-40	2.6-2.9	2-7		6.1-6.8	47-83	226-376		9-16	35-38
								+ Mn (3 g/l) + Zn (3 g/l)	27-40	2.7-3.7	8-10		6.4-7.1	84-116	242-365		11-19	41-43
								+ Fe (3 g/l) + Mn (3 g/l) + Zn (3 g/l)	27-40	2.4-3.1	10-14		5.2-5.3	89-145	410-583		22-25	44-72
2003	Brar and Brar	Gh	LH 1556	India	49 days from flowering	n. d.	Fe	control (75 kg/ha N, 30 kg/ha P)	9.5		24							
								+ 6 x 2 % KNO_3	12.5		25							
								+ 6 x 2 % Urea	11.5		26.7							
								+ 6 x 2 % KCl	14		23.1							
2003	Bronson et al.	Gh	Paymaster Round-up Ready 2326	Texas, US	peak bloom	all leaves of a plant	Fe	well fertilized: 67 kg N/ha	46.2									
								34 kg N/ha	33.5-46.7									
								134 kg N/ha	37.6									
								67 kg N/ha	33.6-37									
								202 kg N/ha	35.6									

Year	Reference	Species[1)]	Variety	Country	Growth stage	Plant part[2)]	Kind of experiment[3)]	Fertilizer treatment	N	P	K	Ca	Mg	Mn	Fe	B	Cu	Zn
									(g/kg dm)					(mg/kg dm)				
								101 kg N/ha	35									
2004	Fritschi et al.	**Gb**	S-7	Califor-nia, US	early bloom	all leaves of a plant	Fe	**56 kg N/ha available to plant**	**37.8-40.7**									
								112 kg N/ha available to plant	**42.5-44.8**									
								168 kg N/ha available to plant	**41.7-45.5**									
								224 kg N/ha available to plant	**43.6-46.6**									
			Maxxa					**56 kg N/ha available to plant**	**39.3-41.9**									
								112 kg N/ha available to plant	**47.3**									
								168 kg N/ha available to plant	**40.5-47.4**									
								224 kg N/ha available to plant	**47.9**									
2004	Fridgen and Varco	Gh	-	Missisip-pi, US	first bloom	fully expanded, recently matured leaves	Fe	0 kg N/ha, 0 kg K/ha	27.2-40.3		6.5							
								45 kg N/ha	34.6-51									
								90 kg N/ha	39-50.2									
								135 kg N/ha	41.9-50-8									
								180 kg N/ha	41.2-52.8									
					peak bloom			0 kg N/ha, 0 kg K/ha	24.4-24.7		4.8-6							
								45 kg N/ha	30.9-31.1									
								90 kg N/ha	32.8-34.1									
								135 kg N/ha	35.6-38.8									
								180 kg N/ha	36.6-42.6									
								112 kg K/ha	36.9-48.9		10.2-10.7							
								112 kg N/ha	32.4-33.3		7.3-9.3							
2005	Kassem and Ahmed	**Gb**	GIZA 83	Egypt	40 days from be-ginning of flowering	4th uppermost leaf	oF, Fe	**control (143 kg/ha N, 24.3 kg/ha P, 0 kg/ha K)**	**27.3-25.7**	**3.0-3.3**	**10.4-11.3**							
								+ 47 kg/ha K as Potassium sulfate)	**29.7-28.6**	**3.6-3.7**	**13.1-13.5**							

Year	Reference	Species[1)]	Variety	Country	Growth stage	Plant part[2)]	Kind of experiment[3)]	Fertilizer treatment	N	P	K	Ca	Mg	Mn	Fe	B	Cu	Zn
									(g/kg dm)					(mg/kg dm)				
								+ 95 kg/ha K as Potassium sulfate)	**32.0-32.2**	**3.9-4.1**	**16.1-16.3**							
2006	Dordas	Gh	Celia	Greece	2 weeks after foliar application	leaves, washed in deionized water	Fe	0 mg/l B								29.8-32.7		
								400 mg/l B								44.4-54.5		
								800 mg/l B								55.4-73.9		
								1 200 mg/l B								78.9-85.1		
2007	Dougall and Kahl	Gh	Bollgard cotton (Sitcot289B, CSX 405) + Ingard cotton (Sicot289i)	Australia		youngest fully unfurled leaves	oF, Fe			11-6								
						youngest mature leaves				6-3								
2009	Dordas	Gh	Celia	Greece	2 weeks after foliar application	leaves, washed in deionized water		0 mg/l Mn						29				
								200 mg/l Mn						45.8-46.3				
								400 mg/l Mn						69.6-71.5				

[1)]Gh=*Gossypium hirsutum*; Gb=*Gossypium barbadense*;
[2)] youngest fully mature leaves on main stem=YFMLMSt;
[3)]oF=on farm experiment; Fe=field experiment; HUAP=heat units after planting

Tab. 8.6: **Fertilization recommendations for cotton (Gossypium barbadense) as result of Egyptian research activities 1980-2010.**

Year	Reference	Cultivar	Water (m^3)	Plant density	Location	N (kg/ha)	as	P (kg/ha)	as	K (kg/ha)	as	Mn (g/ha)		Fe (g/ha)		Zn (g/ha)	
						30-50	clover residue										
						10	FYM: 0-24 m^3/ha										
						50	supply from soil										
1997	El-Sayed et al.					150-220	mineral fertilizer	16-33	mineral fertilizer	47	mineral fertilizer	126	EDTA-chelation, foliar spray, 40 % initial flowering, 60 % boll formation	42	EDTA-chelation, foliar spray, 40 % initial flowering, 60 % boll formation	84	EDTA-chelation, foliar spray, 40 % initial flowering, 60 % boll formation
1997	El Hadi et al.					180		16.3		49.8							
						80		16.3		49.8		x		x		x	
2002	Nofal et al.	GIZA 89		121 600	Gharbia	133	NH_4NO_3, 2 applications, after thinning and at next irrigation	23.6		47.4	K_2SO_4, after thinning	(3g/l)	EDTA-chelation, 14 % Mn, foliar spray at initial flowering, 15 days after 1st app.	(3g/l)	EDTA-chelation, 14 % Fe, foliar spray at initial flowering, 15 days after 1st app.	(3g/l)	EDTA-chelation, 14 % Zn, foliar spray at initial flowering, 15 days after 1st app.
2005	Kassem et al.	GIZA 83			Minya	143	NH_4NO_3	55	after ridging, before planting,	95	K_2SO_4, high price KCl, low price						
2006	Sawan et al.	GIZA 86	6000	123 000	ARC, GIZA	143	NH_4NO_3 +$CaCO_3$, 33,5 % N, 2 applications, 6 and 8 WAP immediate irrigation afterwards			0.32	K_2SO_4, 40 % K_2O, foliar spray, 70 and 95 DAS						
2008	Sawan et al.	GIZA 86	6000	123 000	ARC, GIZA	143	NH_4NO_3 +$CaCO_3$, 33,5 % N, 2 applications, after thinning, before 3rd irrigation	1.73	Ca-superphosphate, 15 % P_2O_5, 2 foliar applications, 80 and 95 DAS	47	K_2SO_4, 48 % K_2O, 8 WAS, band-application					57,6	chelated, 2 foliar applications, 70 and 85 DAS

Tab. 8.7: Origin of soil and plant samples of organically grown Egyptian cotton (*Gossypium barbadense*).

Farm No	Farmer's name	Certification	Governorate	District	2008	2009	2010	GPS-coordinates (N)	GPS-coordinates (E)
152	Tadros	d	Beheira	Abou El Matamer	x			30°59.909	30°03.666
163	El Oraba	d	Beheira	Abou El Matamer	x	x	x	31°02.136'	030°02.920'
256	Amir Gauid	d	Beheira	Abou El Matamer	x			30°59.932	30°03.728
266	Abou Khateeb	d	Beheira	Abou El Matamer	x	x	x	30°58.258'	030°00.055'
266	Abou Khateeb-B	d	Beheira	Abou El Matamer			x	30°58.266'	030°58.248'
266	Abou Khateeb-C	d	Beheira	Abou El Matamer			x	30°58.284'	030°00.081'
273	Salah el Raaie	d	Beheira	Abou El Matamer		x	xxx	31°02.264	030°02.520'
308	Madawy	d	Beheira	Abou El Matamer	x	x	x	31°03.279'	030°01.008'
541	El Dawar	d	Beheira	Kafr Ad Dawwar	x	x		31°08.539	30°09.605
682	Hussein Younis	d	Beheira	Abou El Matamer		x	x	30°58.663'	029°59.643'
683	Shaher el Din	d	Beheira	Abou El Matamer	x		x	31°02.371'	030.02.327'
685	Abou el Eda	d	Beheira	Abou El Matamer	x	x	x	30°56.805'	030°05.384'
686	El Hager	d	Beheira	Abou El Matamer	x	x		31°02.252	29°58.485
688	Mekled	d	Beheira	Abou El Matamer	x	x	x	30°58.403'	029°59.537'
689	Maarouf	d	Beheira	Abou El Matamer	x		x	31°01.881'	030°02.098'
690	Badr	d	Beheira	Abou El Matamer	x	x		31°01.441	29°58.848
710	Fatahallah	o	Beheira	Edko	x	x	x	31°14.616	30°25.457
712	Abo Modawi	d	Beheira	Abou El Matamer			x	31°02.220'	030°02.421'
721	Said Badr	o	Beheira	Edko		x	x	31°14.644	30°25.493
724	El Nagar	o	Beheira	Edko	x	x	x	31°16.702	30°24.583
725	Maray	o	Beheira	Edko	x	x	x	31°15.874	30°24.730
726	Tahar	o	Beheira	Edko		x	x	31°15.789	30°24.770
727	Ghorab	o	Beheira	Edko	x		x	31°15.860	30°24.970
728	Adel Badr	o	Beheira	Edko	x	x	x	31°15.020	30°24.856
729	El Omda	o	Beheira	Edko	x	x	x	31°14.407	30°26.955
732	Yousef Badr	o	Beheira	Edko	x	x	x	31°15.424	30°24.824
733	El Moghazy	o	Beheira	Abou El Matamer	x			31°00.765'	029°58.941'
734	El Ska	o	Beheira	Abou El Matamer	x	x		31°00.823'	029°58.985'
735	Abo Hussein	o	Beheira	Kafr Ad Dawwar	x	x		31°00.201	30°06.201
736	El Askary	o	Beheira	Kafr Ad Dawwar	x	x	xx	31°09.747	29°59.011
737	Gamal el Askary	o	Beheira	Kafr Ad Dawwar		x		31°03.521	30°01.358
739	El Byaly	o	Beheira	Abou El Matamer	x	x		30°59.670	30°00.301
740	Galal	o	Beheira	Abou El Matamer	x	x		30°59.959	30°03.676
741	Abo Shousha	o	Beheira	Abou El Matamer	x	x		31°03.520	30°01.359
743	El Sheikh	o	Beheira	Abou El Matamer	x		x	31°11.185	30°21.538
744	Abou el Rish	o	Beheira	Abou El Matamer		x		30°49.622	30°00.692
745	Abd El Aty	o	Beheira	Abou El Matamer	x			30°49.800	30°01.987
784	Gorab	o	Beheira	Kafr Ad Dawwar		x	x	31°12.522	30°22.872
785	Khamis Badr	o	Beheira	Kafr Ad Dawwar	x	x	x	31°15.409	30°25.517
786	Rahoma	o	Beheira	Kafr Ad Dawwar	x	x	x	31°15.520	30°25.949
787	Hamdan	o	Beheira	Kafr Ad Dawwar		x	x	31°15.485	30°25.732
788	El Sebay	o	Beheira	Kafr Ad Dawwar	x	x	x	n.d.[1)]	n.d.
789	Abd El Mayla	o	Beheira	Kafr Ad Dawwar		x	x	31°15.481	30°25.643
790	Abd El Fatah	o	Beheira	Kafr Ad Dawwar		x	x	31°12.526	30°22.888
753	Awlad Ibrahim	o	Sharqia	Sanel-Hager	x	x	x	30°56.676'	031°50.256'
754	Abo El Magd	o	Sharqia	Sanel-Hager	x	x	x	30°57.205'	031°50.230'
755	Abou Zaed	o	Sharqia	Sanel-Hager	x	x	x	30°57.025'	031°50.910'

Farm No	Farmer's name	Certification	Governorate	District	2008	2009	2010	GPS-coordinates (N)	GPS-coordinates (E)
756	Gad	o	Sharqia	Sanel-Hager	x	x	x	30°57.039'	030°50.927'
757	Salah Hamad	o	Sharqia	Sanel-Hager	x	x	x	30°57.025'	031°50.910'
758	El Kenany	o	Sharqia	Sanel-Hager		x	x	30°57.324'	031°51.161'
759	Anes	o	Sharqia	Hesenia	x	x	x	30°54.258'	032°00.754'
760	El Mazoon	o	Sharqia	Hesenia	x	x	xx	30°54.266'	032°00.782'
761	Ahm. Ibrahim	o	Sharqia	Hesenia	x	x	x	30°55.213'	032°00.641'
762	Moh. Eisa	o	Sharqia	Hesenia	x	x	x	30°55.535'	032°00.553'
763	Abd El Salan	o	Sharqia	Hesenia	x	x		30°55.000	31°00.616
764	Moh. Ebrahim	o	Sharqia	Hesenia	x	x	x	30°55.477'	032°00.487'
765	Abd El Basset	o	Sharqia	Hesenia	x			30°55.630	30°00.296
766	El Egily	o	Sharqia	Hesenia		x		30°54.904	32°00.479
767	Hassan Sarhan	o	Sharqia	Hesenia		x		30°55.695	32°02.350
768	Dabour	o	Sharqia	Sanel-Hager	x	x		31°19.071	31°40.400
769	Abd El Aziz	o	Sharqia	Hesenia	x	x		30°56.379	32°02.593
770	El Debeky	o	Sharqia	Hesenia	x	x	x	30°56.659'	030°01.203'
771	Abd El Raouf	o	Sharqia	Hesenia	x	x		30°57.081	32°00.823
772	Rashad	o	Sharqia	Hesenia	x	x	x	30°56.245'	030°02.072'
773	Zaky	o	Sharqia	Hesenia	x	x		30°56.292'	032°01.302'
774	Amer Khalifa	o	Sharqia	Hesenia	x	x		30°56.983	32°00.867
775	Abd el Latif	o	Sharqia	Sanel-Hager	x	x	x	31°100.417'	031°50.987'
776	Moh. Shehata	o	Sharqia	Sanel-Hager	x	x	x	30°57.324'	031°51.161'
777	El Tahayi	o	Sharqia	Sanel-Hager	x	x		30°54.550	31°52.138
205	Mashour	d	Faiyum	Tameya	x	x	x	29°27.101'	031°03.349'
241	Sakaran	d	Faiyum	El-Faiyum	x	x	x	29°19.547'	030°44.615'
292	El Metwally	d	Faiyum	Tameya	x	x	x	29°25.944'	031°04.053'
311	El Lahloby	d	Faiyum	Manashy El Khateel	x	x		29°17.515	30°14.371
318	Nagy	d	Faiyum	Talat	x	x		29°19.892	30°44.682
444	El Farouk	o	Faiyum	Sediek Yossif	x			29°21.502	30°31.627
457	Habib	d	Faiyum	Manashy El Khateel	x			29°18.137	30°44.965
488	Eraky	d	Faiyum	El-Faiyum	x	x	x	29°19.557'	030°44.657'
613	El Feky	d	Faiyum	Sediek Yossif	x			29°21.771	30°31.990
666	El Salam	o	Faiyum	Sediek Yossif	x			n.d.	n.d.
676	Ghaith	d	Faiyum	El-Faiyum	x			n.d.	n.d.
677	Abo Hamad	d	Faiyum	Abshwey	xx		x	29°23.706'	030°41.610'
6771	Hamad	d	Faiyum	Abshwey	x		x	29°23.655'	030°41.585'
6772	Ahmad	d	Faiyum	Abshwey			x	29°23.564'	030°41.670'
2	Said Rashad	o	Qalyubia	Shebin-El Alater	x			n.d.	n.d.
36	Moh. Mostafa	d	Qalyubia	K. Ahmer	x	x		30°17.422	31°16.640
258	El Azab	d	Qalyubia	K. Ahmer	x			30°17.303	31°15.654
692	Senhera	d	Qalyubia	Toch	x	x	x	30°18.157'	031°14.599'
692	Senhera B	d	Qalyubia	Toch			x	30°18.233'	031°14.637'
692	Senhera C	d	Qalyubia	Toch			x	30°18.179'	030.14.789'
694	Kom El Ahmar	d	Qalyubia	K. Ahmer		x		30°54.548	31°52.152
696	El Zahweyen	d	Qalyubia	Shebin-El Alater		x	x	30°15.519'	031°16.721'
696	El Zahweyen-B	d	Qalyubia	Shebin-El Alater			x	30°15.544'	031°16.786'
778	Hendiaye	o	Qalyubia	K. Ahmer	x			n.d.	n.d.
679	Alfy 1	d	Dakahlia	Sherbin	x	x	x	31°20.595'	031°31.933'
680	Alfy 2	d	Dakahlia	Sherbin	x	x	x	31°20.552'	031°31.913'
7821	Said	d	Damietta	Kafr el ghab			x	31°21.725'	030°31.065'

Farm No	Farmer's name	Certification	Governorate	District	2008	2009	2010	GPS-coordinates (N)	GPS-coordinates (E)
7822	Said	d	Damietta	Kafr el ghab			x	31°21.775'	031°31.067'
					No. of Samples				
					74	68	65		

[1)]n. d.=GPS-coordinates were not determined as cooperation with the farmer has seized, o=certified as organic; d=certified as demeter

Tab. 8.8: Exemplary production system for organically grown cotton (*Gossypium barbadense*) at Beheira governorate.

season	winter 1st year	summer 1st year	winter 2nd year	summer 2nd year	winter 3rd year	summer 3rd year
crop	wheat	rice	berseem clover	melon/sugar beet	berseem clover	cotton
compost m³/fed, with 10 % chicken manure		15-20		15-20		15-20
rock phosphate kg/fed		-		-		-
feldspar kg/fed		-		-		-
sulfur kg/fed		-		-		-
only for biodynamic farms						
quarz (hornkiesel) g/fed		2, 3 times**)		2, 3 times**)		2, 3 times**)
horn manure*)		200		200		200
*)production centralized at SEKEM by EBDA **)time of application: 1st: 2 weeks after first irrigation; 2nd: 1 month after 1st application; 3rd: after flowering ***)only be purchased in case of sufficient financial resources. At the time of interrogation, this was not the case.						

cultivar	GIZA 86
number of plants/ha	123,000
time of application of compost	100 % before seeding or 60 % before seeding and 40 % at hoeing
date of planting/seeding	15th April until 15th May
date of hoeing and weeding	28 days after planting
irrigation system	flood irrigations system
irrigation period	every 2-3 weeks
date of 1st harvest	15th September, when 50-60 % of all bolls are open (irrigation is following)
date of 2nd harvest	1st October
date of 3rd harvest	15th October
vegetation period	170-190 days
insects plagues/plant diseases 2008 and 2009	some ballworms and other insects, but usually this decreased harvest only by 5-6 %
insects plagues/plant diseases 2010	not registered
severe water shortage in 2008 or 2009	no
Severe water shortage in 2010	no
damages due to influence of salt	no

Tab. 8.9: Exemplary production system for organically grown cotton (*Gossypium barbadense*) at Sharqia and Qalyubia governorate.

season	winter 1st year	summer 1st year	winter 2nd year	summer 2nd year	winter 3rd year	summer 3rd year
crop	wheat	rice	berseem	melon/sugar beet	berseem	cotton
compost m³/fed, with 10 % chicken manure		15-20		15-20		15-20
rock phosphate kg/fed		-		-		-
feldspar kg/fed		(30)***)		(30)***)		(30)***)
sulfur kg/fed		(50)***)		(50)***)		(50)***)
only for biodynamic farms						
quarz (hornkiesel) g/fed		2, 3 times**)		2, 3 times**)		2, 3 times**)

season	winter 1st year	summer 1st year	winter 2nd year	summer 2nd year	winter 3rd year	summer 3rd year
horn manure*)		200		200		200

*)production centralized at SEKEM by EBDA
**)time of application: 1st: 2 weeks after first irrigation; 2nd: 1 month after 1st application; 3rd: after flowering
***)only be purchased in case of sufficient financial resources. At the time of interrogation, this was not the case.

cultivar	GIZA 86
number of plants/ha	123,000
time of application of compost	100 % before seeding or 60 % before seeding and 40 % at hoeing
date of planting/seeding	15th March until 15th April
date of hoeing and weeding	28 days after planting
irrigation system	flood irrigations system
irrigation period	every 2-3 weeks
date of 1st harvest	15th August, when 50-60 % of all bolls are open (irrigation is following)
date of 2nd harvest	15th September
date of 3rd harvest	1st October
vegetation period	170-190 days
insects plagues/plant diseases 2008 and 2009	some ballworms and other insects, but usually this decreased harvest only by 5-6 %
insects plagues/plant diseases 2010	not registered
severe water shortage in 2008, 2009 or 2010	no
damages due to influence of salt	yes, very heavy soils

Tab. 8.10: Exemplary production system for organically grown cotton (*Gossypium barbadense*) at Dakahlia and Damietta governorate.

season	winter 1st year	summer 1st year	winter 2nd year	summer 2nd year
crop	wheat	rice	berseem clover/bean	cotton
compost m³/fed, from animal manure, rice dust, organic farm waste		15		15
rock phosphate kg/fed*)		30		30
feldspar kg/fed*)		30		30
sulfur (Solvit) kg/fed		50		50
*) added with 2 kg per running meter of compost-pile				
only for biodynamic farms				
quarz (hornkiesel) g/fed		2, 3 times***)		2, 3 times***)
horn manure**)		200		200

**) Production centralized at SEKEM by EBDA
***) time of application: 1st: 2 weeks after first irrigation; 2nd: 1 month after 1st application; 3rd: after flowering

cultivar	GIZA 85
number of plants/ha	123,000
time of application of compost	100 % before seeding or 60 % before seeding and 40 % at hoeing
date of planting/seeding	1st April until 15th April
date of hoeing and weeding	28 days after planting
irrigation system	flood irrigations system
irrigation period	every 2-3 weeks
date of 1st harvest	15th September, when 50-60 % of all bolls are open (irrigation is following)
date of 2nd harvest	1st October
date of 3rd harvest	end of November
vegetation period	210 days
insects plagues/plant diseases 2008 and 2009	some ballworms and other insects, but usually this decreased harvest only by 5-6 %
insects plagues/plant diseases 2010	not registered
severe water shortage in 2008, 2009 or 2010	no
damages due to influence of salt	no

Tab. 8.11: Exemplary production system for organically grown cotton (*Gossypium barbadense*) at Faiyum governorate.

season	**winter 1st year**	**summer 1st year**	**winter 2nd year**	**summer 2nd year**	**winter 3rd year**	**summer 3rd year**
crop	wheat	maize	beans	sorghum/rice	berseem	cotton
compost m³/fed, with 10 % chicken manure		15-20		15-20		15-20
rock phosphate kg/fed		(50)***)		(50)***)		(50)***)
feldspar kg/fed		(50)***)		(50)***)		(50)***)
sulfur kg/fed		(50)***)		(50)***)		(50)***)
only for biodynamic farms						
quarz (hornkiesel) g/fed		2, 3 times**)		2, 3 times**)		2, 3 times**)
horn manure*)		200		200		200
*)production centralized at SEKEM by EBDA **)time of application: 1st: 2 weeks after first irrigation; 2nd: 1 month after 1st application; 3rd: after flowering ***)only be purchased in case of sufficient financial resources. At the time of interrogation, this was not the case.						
cultivar	GIZA 90					
number of plants/ha	123,000					
time of application of compost	100 % before seeding or 60 % before seeding and 40 % at hoeing					
date of planting/seeding	1st March until 1st April					
date of hoeing and weeding	28 days after planting					
irrigation system	flood irrigations system					
irrigation period	every 2-3 weeks					
date of 1st harvest	1st August, when 80 % of all bolls are open (irrigation is following)					
date of 2nd harvest	during September					
date of 3rd harvest	none					
vegetation period	170-180 days					
insects plagues/plant diseases 2008 and 2009	some ballworms and other insects, but usually this decreased harvest only by 5-6 %					
insects plagues/plant diseases 2010	not registered					
severe water shortage in 2008, or 2009 and 2010	yes					
damages due to influence of salt	no					

Tab. 8.12: Characterization of sampling sites for soil and leaf tissue samples of organically grown cotton (*Gossypium barbadense*) in Egypt (sampling: 2008-2010): general information and soil characteristics.

Farm no	**Farm**	**Site**	**Site no.[1)]**	**District**	**Certification[2)]**	**Year[3)]**	**Production [kg/ha]**	**Rel. production [%]**	**Variety[4)]**	**Soil structure[5)]**	**Carbonates visible[6)]**	**Soil colour[7)]**	**pH**	**C_{total}**	**C_{org}**	**$CaCO_3$**
2	Said Rashad	Qalyubia	6	Sherbin El Ala	2	1	3,375	94	2	1	2	2	7.8	1.3	-	-
36	Moh. Mostafa	Qalyubia	6	K. Ahmer	1	1	3,675	103	2	2	2	3	8.0	1.7	-	-
36	Moh. Mostafa	Qalyubia	6	K. Ahmer	1	2	4,500	134	2	2	2	3	7.6	1.7	-	-
152	Tadros	Beheira-W	1	Abou El Matamer	1	1	3,750	105	2	2	1	2	7.9	3.7	-	-
163	El Oraba	Beheira-W	1	Abou El Matamer	1	1	4,125	115	2	2	1	2	7.9	3.8	-	-
163	El Oroba	Beheira-W	1	Abou El Matamer	1	2	4,219	125	2	2	1	2	7.6	2.9	-	-
163	El Oroba	Beheira-W	1	Abou El Matamer	1	3	3,750	108	2	2	1	2	7.9	3.5	-	-
205	Mashour	Faiyum	7	Tameya	1	1	3,375	94	3	3	2	3	7.9	2.7	-	-
205	Mashour	Faiyum	7	Tameya	1	2	3,317	99	3	3	2	3	7.9	1.3	0.8	3.9
205	Mashour	Faiyum	7	Tameya	1	3	3,262	94	3	3	2	3	8.0	2.5	1.0	12.4
241	Sakaran	Faiyum	7	El-Faiyum	1	1	3,528	99	3	2	2	3	7.9	1.8	1.4	3.2
241	Sakaran	Faiyum	7	El-Faiyum	1	2	2,336	69	3	4	2	3	7.7	1.5	0.6	7.3
241	Sakaran	Faiyum	7	El-Faiyum	1	3	3,327	96	3	2	2	3	8.1	1.4	0.4	8.5
256	Amir Gauid	Beheira-W	1	Abou El Matamer	1	1	3,750	105	2	2	1	2	7.8	3.7	-	-
258	El Azab	Qalyubia	6	K. Ahmer	1	1	3,375	94	2	1	1	3	7.8	1.3	-	-
266	Abou Khateeb	Beheira-W	1	Abou El Matamer	1	1	3,984	111	2	3	1	1	7.9	3.7	1.6	17.5
266	Abou Khateeb	Beheira-W	1	Abou El Matamer	1	2	4,500	134	2	3	1	1	7.6	3.0	2.0	8.7

Farm no	Farm	Site	Site no.[1]	District	Certification[2]	Year[3]	Production [kg/ha]	Rel. production [%]	Variety[4]	Soil structure[5]	Carbonates visible[6]	Soil colour[7]	pH	C_{total}	C_{org}	$CaCO_3$
266	Abou Khateeb-B	Beheira-W	1	Abou El Matamer	1	3	3,553	102	2	3	1	1	7.9	5.4	1.7	30.2
266	Abou Khateeb-A	Beheira-W	1	Abou El Matamer	1	3	3,553	102	2	3	1	1	7.9	4.8	1.9	24.7
266	Abou Khateeb-C	Beheira-W	1	Abou El Matamer	1	3	3,553	102	2	3	1	1	7.9	5.3	2.0	28.0
273	Salah el Raaie	Beheira-W	1	Abou El Matamer	1	2	2,605	77	2	3	1	1	7.6	3.0	1.6	11.9
273	Salah el Raaie	Beheira-W	1	Abou El Matamer	1	3	3,516	101	2	3	1	1	8.0	2.8	0.9	15.3
273	Salah el Raaie	Beheira-W	1	Abou El Matamer	1	3	3,516	101	2	3	1	1	8.0	2.8	0.9	15.3
273	Salah el Raaie	Beheira-W	1	Abou El Matamer	1	3	3,516	101	2	3	1	1	8.0	2.8	0.9	15.3
292	El Metwally	Faiyum	7	Tameya	1	1	3,000	84	3	2	2	2	7.9	3.8	1.8	17.0
292	El Metwally	Faiyum	7	Tameya	1	2	2,727	81	3	2	2	2	7.9	1.3	0.8	4.0
292	El Metwally	Faiyum	7	Tameya	1	3	3,375	97	3	2	2	2	7.8	3.2	1.2	16.6
308	Madawy	Beheira-W	1	Abou El Matamer	1	1	4,018	112	2	3	1	1	7.8	3.5	1.5	17.2
308	Madawy	Beheira-W	1	Abou El Matamer	1	2	4,167	124	2	3	1	1	7.8	3.0	1.8	10.3
308	Madawy	Beheira-W	1	Abou El Matamer	1	3	3,750	108	2	3	1	1	7.9	3.5	1.4	17.5
311	El Lahloby	Faiyum	7	Manashy El Kha	1	1	3,750	105	3	3	2	3	7.8	1.9	-	-
311	El Lahloby	Faiyum	7	Manashy El Kha	1	2	2,588	77	3	3	2	3	8.1	1.3	-	-
318	Nagy	Faiyum	7	Talat	1	1	3,000	84	3	24	2	3	7.8	3.1	-	-
318	Nagy	Faiyum	7	Talat	1	2	3,000	89	3	24	2	3	7.9	1.4	-	-
444	El Farouk	Faiyum	7	Jusif	2	1	3,125	87	3	24	2	3	7.8	2.0	-	-
457	Habib	Faiyum	7	Manashy El Kha	1	1	3,449	97	3	3	2	3	8.1	1.8	-	-
488	Eraky	Faiyum	7	El-Faiyum	1	1	3,000	84	3	3	2	3	7.9	2.5	1.3	9.9
488	Eraky	Faiyum	7	El-Faiyum	1	2	3,594	107	3	3	2	3	8.0	1.6	0.7	7.8
488	Eraky	Faiyum	7	El-Faiyum	1	3	3,150	91	3	3	2	3	8.2	1.3	0.4	7.5
541	El Dawar	Beheira-O	2	Kafr Ad Dawwar	1	1	4,375	122	2	13	3	3	7.9	3.4	-	-
541	El Dawar	Beheira-O	2	Kafr Ad Dawwar	1	2	3,913	116	2	13	3	3	7.8	2.9	-	-
613	El Feky	Faiyum	7	Sediek Yossif	1	1	2,881	81	3	24	2	3	8.1	2.0	-	-
666	El Salam	Faiyum	7	Sediek Yossif	2	1	3,375	94	3	24	2	3	8.2	1.3	-	-
676	Ghaith	Faiyum	7	El-Faiyum	1	1	2,963	83	3	23	2	3	8.1	2.6	-	-
677	Abo Hamad-A	Faiyum	7	Abshwey	1	1	4,145	116	3	2	2	2	8.1	1.4	0.4	8.0
677	Abo Hamad-B	Faiyum	7	Abshwey	1	1	2,940	82	3	4	2	2	8.1	1.4	0.4	8.0
677	Abo Hamad	Faiyum	7	Abshwey	1	3	3,000	87	3	2	2	2	8.2	1.7	0.7	8.8
679	Alfy 1	Dakahl.-Da	5	Sherbin	1	1	3,375	94	1	2	2	3	7.8	1.7	-	-
679	Alfy 1	Dakahl.-Da	5	Sherbin	1	2	3,000	89	1	2	2	3	7.9	1.7	-	-
679	Alfy 1	Dakahl.-Da	5	Sherbin	1	3	3,375	97	1	2	2	3	8.0	1.6	-	-
680	Alfy 2	Dakahl.-Da	5	Sherbin	1	1	3,132	88	1	14	2	3	7.9	1.7	1.3	3.0
680	Alfy 2	Dakahl.-Da	5	Sherbin	1	2	2,813	84	1	14	2	3	8.0	1.7	0.9	6.2
680	Alfy 2	Dakahl.-Da	5	Sherbin	1	3	3,188	92	1	14	2	3	7.9	1.8	1.0	5.9
682	Hussein Younis	Beheira-W	1	Abou El Matamer	1	2	3,553	106	2	3	1	1	7.7	2.5	1.3	9.8
682	Hussein Younis	Beheira-W	1	Abou El Matamer	1	3	3,250	94	2	3	1	1	7.8	4.2	1.5	22.2
683	Shaher el Din	Beheira-W	1	Abou El Matamer	1	1	3,750	105	2	3	1	1	7.8	2.7	0.7	16.4
683	Shahar el Din	Beheira-W	1	Abou El Matamer	1	3	3,150	91	2	3	1	1	8.0	3.2	0.9	19.1
685	Abou el Eda	Beheira-W	1	Abou El Matamer	1	1	4,329	121	2	3	1	1	7.9	2.2	-	-
685	Abou el Eda	Beheira-W	1	Abou El Matamer	1	2	4,219	125	2	3	1	1	8.3	0.7	-	-
685	Abou el Eda	Beheira-W	1	Abou El Matamer	1	3	3,542	102	2	3	1	1	7.9	4.1	-	-
686	El Hager	Beheira-W	1	Abou El Matamer	1	1	3,750	105	2	3	1	1	8.0	3.4	-	-
686	El Hager	Beheira-W	1	Abou El Matamer	1	2	4,125	123	2	3	1	1	8.4	1.3	-	-
688	Mekled	Beheira-W	1	Abou El Matamer	1	1	3,847	108	2	3	1	1	7.8	2.1	1.7	2.9
688	Mekled	Beheira-W	1	Abou El Matamer	1	2	4,228	126	2	3	1	1	7.9	2.8	1.7	8.8
688	Mekled	Beheira-W	1	Abou El Matamer	1	3	3,500	101	2	3	1	1	8.0	4.5	1.1	28.2
689	Maarouf	Beheira-W	1	Abou El Matamer	1	1	3,750	105	2	3	1	1	7.8	2.8	-	-
689	Maarouf	Beheira-W	1	Abou El Matamer	1	3	3,516	101	2	3	1	1	7.9	3.3	0.9	19.9
690	Badr	Beheira-W	1	Abou El Matamer	1	1	4,250	119	2	35	1	1	7.9	3.7	-	-
690	Badr	Beheira-W	1	Abou El Matamer	1	2	3,348	100	2	35	1	1	7.8	2.9	-	-
692	Senhera	Qalyubia	6	Toch	1	1	2,961	83	2	2	2	3	7.9	1.4	-	-
692	Senhera	Qalyubia	6	Toch	1	2	3,000	89	2	2	2	3	7.8	1.9	-	-
692	Senhera-A	Qalyubia	6	Toch	1	3	3,750	108	2	2	2	3	8.0	1.6	0.8	6.4
692	Senhera-B	Qalyubia	6	Toch	1	3	3,750	108	2	2	2	3	7.9	1.7	1.1	4.7

Farm no	Farm	Site	Site no.[1)]	District	Certification[2)]	Year[3)]	Production [kg/ha]	Rel. production [%]	Variety[4)]	Soil structure[5)]	Carbonates visible[6)]	Soil colour[7)]	pH	C_{total}	C_{org}	$CaCO_3$
692	Senhera-C	Qalyubia	6	Toch	1	3	3,750	108	2	2	2	3	7.8	1.9	1.5	3.9
694	Kom El Ahmar	Qalyubia	6	K. Ahmer	1	2	2,625	78	2	2	2	3	8.0	1.8	-	-
696	El Zahweyen	Qalyubia	6	Sherbin El Ala	1	2	3,000	89	2	2	2	3	7.8	1.5	0.7	6.5
696	El Zahweyen-A	Qalyubia	6	Sherbin El Ala	1	3	3,375	97	2	2	2	3	8.0	1.6	0.9	5.5
696	El Zahweyen-B	Qalyubia	6	Sherbin El Ala	1	3	3,375	97	2	2	2	3	8.0	1.3	0.6	6.3
710	Fathahallah	Beheira-O	2	Edko	2	1	4,063	114	2	13	1	1	7.8	2.0	1.8	1.2
710	Fathahallah	Beheira-O	2	Edko	2	2	3,263	97	2	2	2	3	7.8	3.7	1.5	18.2
710	Fathahallah	Beheira-O	2	Edko	2	3	3,640	105	2	13	1	1	7.9	2.0	1.0	7.7
712	Abo Modawi	Beheira-W	1	Abou El Matamer	1	3	3,750	108	2	3	1	1	7.9	4.1	-	-
721	Said Badr	Beheira-O	2	Edko	2	2	3,563	106	2	3	1	1	7.8	3.9	1.8	17.5
721	Said Badr	Beheira-O	2	Edko	2	3	3,750	108	2	13	1	1	7.9	1.8	1.2	5.0
724	El Nagar	Beheira-O	2	Edko	2	1	3,750	105	2	3	2	2	8.9	1.4	1.0	3.3
724	El Nagar	Beheira-O	2	Edko	2	2	3,375	100	2	3	2	2	7.8	4.2	1.7	20.9
724	El Nagar	Beheira-O	2	Edko	2	3	3,297	95	2	3	2	2	7.8	2.0	1.5	4.1
725	Maray	Beheira-O	2	Edko	2	1	4,327	121	2	1	1	1	7.9	2.9	1.4	12.1
725	Maray	Beheira-O	2	Edko	2	2	3,938	117	2	1	1	1	7.8	4.2	1.5	22.7
725	Maray	Beheira-O	2	Edko	2	3	3,563	103	2	1	1	1	7.8	2.1	1.5	5.0
726	Tahar	Beheira-O	2	Edko	2	2	3,375	100	2	13	1	1	7.8	4.1	1.5	22.0
726	Tahar	Beheira-O	2	Edko	2	3	3,750	108	2	13	1	1	7.8	2.0	1.5	4.1
727	Ghorab	Beheira-O	2	Edko	2	1	4,500	126	2	13	1	1	7.8	2.8	2.4	3.4
727	Ghorab	Beheira-O	2	Edko	2	3	3,176	92	2	13	1	1	7.9	1.9	0.9	8.0
728	Adel Badr	Beheira-O	2	Edko	2	1	4,261	119	2	3	1	1	7.4	4.6	4.3	2.0
728	Adel Badr	Beheira-O	2	Edko	2	2	3,625	108	2	3	1	1	7.8	4.5	1.4	25.7
728	Adel Badr	Beheira-O	2	Edko	2	3	3,750	108	2	3	1	1	7.9	2.0	1.5	4.5
729	El Omda	Beheira-O	2	Edko	2	1	4,054	113	2	13	1	1	8.9	1.6	0.4	10.3
729	El Omda	Beheira-O	2	Edko	2	2	3,713	110	2	13	1	1	7.8	4.1	1.4	22.8
729	El Omda	Beheira-O	2	Edko	2	3	3,750	108	2	13	1	1	8.0	1.8	1.1	5.3
732	Yousef Badr	Beheira-O	2	Edko	2	1	4,688	131	2	13	1	1	8.9	1.2	0.4	7.1
732	Yousef Badr	Beheira-O	2	Edko	2	2	3,750	112	2	13	1	1	7.8	2.9	2.2	6.0
732	Yousef Badr	Beheira-O	2	Edko	2	3	3,750	108	2	13	1	1	7.8	2.2	1.4	6.4
733	El Moghazy	Beheira-O	2	Kafr Ad Dawwar	2	1	3,900	109	2	3	1	1	7.8	3.4	-	-
734	El Ska	Beheira-O	2	Kafr Ad Dawwar	2	1	3,879	109	2	3	2	3	8.0	2.9	-	-
734	El Ska	Beheira-O	2	Kafr Ad Dawwar	2	2	3,375	100	2	3	2	3	7.7	1.7	-	-
735	Abo Hussein	Beheira-O	2	Kafr Ad Dawwar	2	1	3,750	105	2	13	3	3	7.9	2.3	-	-
735	Abou Housin	Beheira-O	2	Kafr Ad Dawwar	2	2	3,188	95	2	13	3	3	8.4	0.7	-	-
736	El Askary	Beheira-O	2	Kafr Ad Dawwar	2	2	3,375	100	2	13	1	1	7.7	2.0	1.2	6.4
736	El Askary-A	Beheira-O	2	Kafr Ad Dawwar	1	3	3,000	87	2	13	1	1	7.8	2.6	0.9	14.2
736	El Askary-B	Beheira-O	2	Kafr Ad Dawwar	1	3	3,000	87	2	13	1	1	8.1	2.0	1.3	6.1
737	Gamal el Askar	Beheira-W	1	Abou El Matamer	2	2	3,964	118	2	13	3	3	7.8	3.0	-	-
739	El Byaly	Beheira-W	2	Abou El Matamer	2	1	4,439	124	2	3	1	1	7.9	3.6	-	-
739	El Byaly	Beheira-W	1	Abou El Matamer	2	2	4,021	120	2	3	1	1	8.5	0.8	-	-
740	Galal	Beheira-W	1	Abou El Matamer	2	1	4,022	113	2	3	1	1	7.9	3.6	-	-
740	Galal	Beheira-W	1	Abou El Matamer	2	2	3,188	95	2	3	1	1	7.7	2.0	-	-
741	Abo Shousha	Beheira-W	1	Abou El Matamer	2	1	3,984	111	2	3	1	1	7.9	3.5	-	-
741	Abo Shousha	Beheira-W	1	Abou El Matamer	2	2	1,841	55	2	3	1	1	7.7	2.0	-	-
743	El Sheikh	Beheira-O	2	Kafr Ad Dawwar	2	1	4,313	121	2	5	1	1	7.8	2.7	2.2	4.3
743	El Sheikh	Beheira-O	2	Kafr Ad Dawwar	2	3	3,775	109	2	5	1	1	7.9	2.0	1.5	3.6
744	Abou el Rish	Beheira-O	2	Kafr Ad Dawwar	2	2	3,439	102	2	13	3	3	8.5	0.7	-	-
745	Abd El Aty	Beheira-W	1	Abou El Matamer	2	1	3,989	112	2	3	1	1	7.9	3.5	-	-
753	Awlad Ibrahim	Sharqia-W	3	Sanel-Hager	2	1	3,075	86	2	5	2	3	8.0	1.5	0.7	7.1
753	Awlad Ibrahim	Sharqia-W	3	Sanel-Hager	2	2	3,750	112	2	5	2	3	7.8	1.6	1.3	2.5
753	Awlad Ibrahim	Sharqia-W	3	Sanel-Hager	2	3	3,000	87	2	5	2	3	7.8	1.5	0.7	7.3
754	Abo El Magd	Sharqia-W	3	Sanel-Hager	2	1	3,375	94	2	15	2	2	7.9	1.3	0.7	5.5
754	Abo El Magd	Sharqia-W	3	Sanel-Hager	2	2	3,375	100	2	15	2	2	7.9	1.7	1.5	1.2
754	Abo El Magd	Sharqia-W	3	Sanel-Hager	2	3	2,382	69	2	15	2	2	7.9	1.5	0.6	7.3
755	Abou Zaed	Sharqia-W	3	Sanel-Hager	2	1	3,000	84	2	5	2	-	7.9	1.7	1.0	6.2

Farm no	Farm	Site	Site no.[1]	District	Certification[2]	Year[3]	Production [kg/ha]	Rel. production [%]	Variety[4]	Soil structure[5]	Carbonates visible[6]	Soil colour[7]	pH	C_{total}	C_{org}	$CaCO_3$
755	Abou Zaed	Sharqia-W	3	Sanel-Hager	2	2	2,625	78	2	5	2	-	7.9	1.7	2.1	-3.8
755	Abou Zaed	Sharqia-W	3	Sanel-Hager	2	3	2,250	65	2	5	2	-	7.8	1.8	0.9	7.5
756	Gad	Sharqia-W	3	Sanel-Hager	2	1	3,375	94	2	15	2	2	8.0	1.7	-	-
756	Gad	Sharqia-W	3	Sanel-Hager	2	2	3,375	100	2	15	2	2	7.8	1.7	-	-
756	Gad	Sharqia-W	3	Sanel-Hager	2	3	2,625	76	2	15	2	2	7.7	1.7	1.1	4.4
757	Salah Hamad	Sharqia-W	3	Sanel-Hager	2	1	3,750	105	2	15	2	2	7.9	1.6	1.2	3.3
757	Salah Hamed	Sharqia-W	3	Sanel-Hager	2	2	2,898	86	2	15	2	2	7.9	1.8	2.6	-7.2
757	Salah Hamad	Sharqia-W	3	Sanel-Hager	2	3	3,125	90	2	15	2	2	7.9	1.8	0.6	9.6
758	El Kenany	Sharqia-W	3	Sanel-Hager	2	2	3,375	100	2	5	2	2	7.9	1.7	1.4	2.9
758	El Kenany	Sharqia-W	3	Sanel-Hager	2	3	3,000	87	2	5	2	2	7.9	1.4	0.3	9.1
759	Anes	Sharqia-O	4	Hesenia	2	1	3,750	105	2	1	2	2	7.7	0.9	2.3	-11.9
759	Anes	Sharqia-O	4	Hesenia	2	2	3,000	89	2	1	2	2	7.9	1.0	0.6	3.8
759	Anes	Sharqia-O	4	Hesenia	2	3	3,750	108	2	1	2	2	7.9	0.8	0.3	3.9
760	El Mazoon	Sharqia-O	4	Hesenia	2	1	3,000	84	2	1	2	2	7.8	1.0	1.0	0.4
760	El Mazoon	Sharqia-O	4	Hesenia	2	2	3,000	89	2	1	2	2	7.9	1.1	0.6	4.3
760	El Mazoon	Sharqia-O	4	Hesenia	2	3	3,563	103	2	1	2	2	8.1	-	-	-
760	El Mazoon	Sharqia-O	4	Hesenia	2	3	3,563	103	2	1	2	2	7.9	1.0	0.4	4.7
761	Ahmad Ibraim	Sharqia-O	4	Hesenia	2	1	3,393	95	2	1	2	2	7.7	1.3	1.7	-3.2
761	Ahmad Ibraim	Sharqia-O	4	Hesenia	2	2	3,750	112	2	1	2	2	7.8	1.4	0.9	4.0
761	Ahmad Ibraim	Sharqia-O	4	Hesenia	2	3	3,750	108	2	1	2	2	7.9	1.3	0.6	5.6
762	Moh. Eisa	Sharqia-O	4	Hesenia	2	1	2,986	84	2	1	2	2	8.0	0.8	1.1	-2.3
762	Moh. Eisa	Sharqia-O	4	Hesenia	2	2	3,333	99	2	1	2	2	7.9	1.0	0.5	4.8
762	Moh. Eisa	Sharqia-O	4	Hesenia	2	3	3,750	108	2	1	2	2	8.0	0.9	0.2	5.4
763	Abd El Salam	Sharqia-O	4	Hesenia	2	1	3,735	105	2	5	2	3	7.7	1.3	-	-
763	Abd El Salam	Sharqia-O	4	Hesenia	2	2	3,508	104	2	5	2	3	8.1	1.4	-	-
764	Moh. Ebrahim	Sharqia-O	4	Hesenia	2	1	3,750	105	2	15	2	2	8.0	-	0.4	-
764	Moh. Ebrahim	Sharqia-O	4	Hesenia	2	2	3,750	112	2	1	2	2	7.9	1.1	1.1	-0.1
764	Moh. Ebrahim	Sharqia-O	4	Hesenia	2	3	3,375	97	2	1	2	2	8.0	0.9	0.4	3.6
765	Abd El Basset	Sharqia-O	4	Hesenia	2	1	3,375	94	2	1	2	2	7.7	1.2	-	-
766	El Egily	Sharqia-O	4	Hesenia	2	2	3,021	90	2	1	2	2	7.9	1.1	-	-
767	Hassan Sarhan	Sharqia-O	4	Hesenia	2	2	2,363	70	2	1	2	2	7.9	1.0	-	-
768	Dabour	Sharqia-O	4	Hesenia	2	1	3,000	84	2	5	2	2	7.9	1.0	-	-
768	Dabour	Sharqia-O	4	Hesenia	2	2	3,571	106	2	1	2	2	7.8	1.1	-	-
769	Abd El Aziz	Sharqia-O	4	Hesenia	2	1	2,625	73	2	1	2	2	8.0	1.3	-	-
769	Abd El Aziz	Sharqia-O	4	Hesenia	2	2	3,375	100	2	5	2	2	7.9	1.1	-	-
770	El Debeky	Sharqia-O	4	Hesenia	2	1	3,375	94	2	1	2	2	8.0	0.8	-	-
770	El Debeky	Sharqia-O	4	Hesenia	2	2	3,188	95	2	1	2	2	8.0	1.1	-	-
770	El Debeky	Sharqia-O	4	Hesenia	2	3	3,750	108	2	1	2	2	8.0	0.7	-	-
771	Abd El Raouf	Sharqia-O	4	Hesenia	2	1	3,750	105	2	1	2	1	7.9	1.1	-	-
771	Abd El Raouf	Sharqia-O	4	Hesenia	2	2	3,375	100	2	1	2	1	7.9	1.0	-	-
772	Rashad	Sharqia-O	4	Hesenia	2	1	3,375	94	2	1	2	2	7.8	1.6	0.5	9.4
772	Rashad	Sharqia-O	4	Hesenia	2	2	3,750	112	2	1	2	2	7.9	1.1	0.5	5.3
772	Rashad	Sharqia-O	4	Hesenia	2	3	3,750	108	2	1	2	2	8.0	1.1	0.5	5.1
773	Zaky	Sharqia-O	4	Hesenia	2	1	3,375	94	2	1	2	2	7.9	1.2	0.4	6.5
773	Zaky	Sharqia-O	4	Hesenia	2	3	3,750	108	2	1	2	2	7.9	1.1	0.5	5.3
774	Amer Khalifa	Sharqia-W	3	Sanel-Hager	2	1	3,000	84	2	15	2	2	7.9	1.6	-	-
774	Amer Khalifa	Sharqia-W	3	Sanel-Hager	2	2	3,000	89	2	1	2	2	7.9	1.6	-	-
775	Abd el Latif	Sharqia-W	3	Sanel-Hager	2	1	3,375	94	2	15	2	2	7.9	1.7	1.0	5.4
775	Abd el Latif	Sharqia-W	3	Sanel-Hager	2	2	3,375	100	2	15	2	2	7.9	1.7	1.6	0.3
775	Abd el Latif	Sharqia-W	3	Sanel-Hager	2	3	3,000	87	2	15	2	2	8.1	1.5	1.0	3.9
776	Moh. Shehata	Sharqia-W	3	Sanel-Hager	2	1	3,750	105	2	1	2	2	7.8	1.6	0.9	5.2
776	Moh. Shehata	Sharqia-W	3	Sanel-Hager	2	2	3,355	100	2	1	2	2	7.8	1.6	0.8	6.4
776	Moh. Shehata	Sharqia-W	3	Sanel-Hager	2	3	3,000	87	2	1	2	2	7.9	1.1	0.2	7.3
777	El Tahayi	Sharqia-W	3	Sanel-Hager	2	1	3,000	84	2	15	2	2	8.8	1.1	-	-
777	El Tahayi	Sharqia-W	3	Sanel-Hager	2	2	3,000	89	2	15	2	2	7.9	1.7	-	-
778	Hendiaye	Qalyubia	6	K.Ahmer	2	1	3,469	97	2	2	2	3	8.1	1.5	-	-

Farm no	Farm	Site	Site no.[1)]	District	Certification[2)]	Year[3)]	Production [kg/ha]	Rel. production [%]	Variety[4)]	Soil structure[5)]	Carbonates visible[6)]	Soil colour[7)]	pH	C_{total}	C_{org}	$CaCO_3$
784	Gorab	Beheira-O	2	Kafr Ad Dawwar	2	2	3,375	100	2	13	3	3	7.8	4.0	1.3	22.0
784	Gorab	Beheira-O	2	Kafr Ad Dawwar	2	3	3,750	108	2	13	3	3	7.8	2.0	1.4	5.0
785	Khamis Badr	Beheira-O	2	Kafr Ad Dawwar	2	1	4,688	131	2	2	1	1	7.9	4.1	-	-
785	Khamis Badr	Beheira-O	2	Kafr Ad Dawwar	2	2	3,455	103	2	2	1	1	7.8	4.3	1.9	20.0
785	Khamis Badr	Beheira-O	2	Kafr Ad Dawwar	2	3	3,375	97	2	2	1	1	7.9	1.7	1.0	5.4
786	Rahoma	Beheira-O	2	Kafr Ad Dawwar	2	1	4,063	114	2	13	3	3	7.7	2.4	1.9	3.8
786	Rahoma	Beheira-O	2	Kafr Ad Dawwar	2	2	3,527	105	2	13	3	3	7.8	3.9	1.6	19.1
786	Rahoma	Beheira-O	2	Kafr Ad Dawwar	2	3	3,750	108	2	13	3	3	7.8	2.1	1.6	4.6
787	Hamdan	Beheira-O	2	Kafr Ad Dawwar	2	2	3,825	114	2	13	3	3	7.8	4.2	1.2	24.8
787	Hamdan	Beheira-O	2	Kafr Ad Dawwar	2	3	3,571	103	2	13	3	3	7.8	2.0	1.5	3.9
788	El Sebay	Beheira-O	2	Kafr Ad Dawwar	2	1	4,286	120	2	13	3	3	7.8	2.2	1.4	6.7
788	El Sebay	Beheira-O	2	Kafr Ad Dawwar	2	2	2,250	67	2	13	3	3	7.7	3.7	1.4	18.8
788	El Sebay	Beheira-O	2	Kafr Ad Dawwar	2	3	3,750	108	2	13	3	3	7.8	2.0	1.5	4.0
789	Abd El Mayla	Beheira-O	2	Kafr Ad Dawwar	2	2	3,750	112	2	3	2	2	7.8	3.8	1.3	20.9
789	Abd El Mayla	Beheira-O	2	Kafr Ad Dawwar	2	3	3,587	103	2	3	2	2	7.8	2.1	1.6	4.0
790	Abd El Fatah	Beheira-O	2	Kafr Ad Dawwar	2	2	3,000	89	2	2	3	3	7.8	3.1	2.0	8.7
790	Abd El Fatah	Beheira-O	2	Kafr Ad Dawwar	2	3	3,587	103	2	13	3	3	7.9	1.8	0.9	7.8
6771	Hamad	Faiyum	7	Abshwey	1	1	2,813	79	3	24	2	2	8.1	1.4	0.7	5.4
6771	Hamad	Faiyum	7	Abshwey	1	3	3,000	87	3	4	2	2	8.1	1.6	0.5	9.3
6772	Ahmad	Faiyum	7	Abshwey	1	3	3,413	98	3	24	2	2	8.0	1.6	0.6	8.0
7821	Said	Dakahl.-Da	5	Kafr El Ghab	1	1	3,231	90	1	14	2	3	7.9	2.0	1.5	4.3
7821	Said	Dakahl.-Da	5	Kafr El Ghab	1	3	3,000	87	1	14	2	3	7.9	1.5	1.0	4.0
7822	Said	Dakahl.-Da	5	Kafr El Ghab	1	3	3,000	87	1	14	2	3	8.1	1.7	1.1	5.3

[1)]Site no: 1=Beheira-O, 2=Beheira-W, 3=Sharqia-O, 4=Sharqia-W, 5=Dakah.-Dam., 6=Qalyubia, 7=Faiyum
[2)]Certification: 1=demeter, 2=organic
[3)]Year: 1=2008, 2=2009, 3=2010
[4)]Cultivar: 1=GIZA 85, 2=GIZA 86, 4=GIZA 90
[5)]Soil structure: 1=Tl, 2=Lu, 3=Ls, 4=Lt, 5=Ts, 13=Tl-Ls, 14=Tl-Lt, 15=Tl-Ts, 23=Lu-Ls, 24=Lu-Lt, 35=Ls-Ts
[6)]Carbonates visible: 1=yes, 2=no, 3=not determined
[7)]Colour: 1=light, 2=dark, 3=not determined

Tab. 8.13: Results of chemical soil analysis of fields cultivated with organic cotton (*Gossypium barbadense*) in Egypt in 2008-2010.

Farm no.	Year	N_{total} [%]	P_{H2O} [mg/kg]	P_{CAL} [mg/kg]	P_{LE} [mg/kg]	P_{Olsen} [mg/kg]	S_{LE} [mg/kg]	K_{CAL} [mg/kg]	K_{LE} [mg/kg]	Ca_{LE} [mg/kg]	$Mg_{Schacht}$ [mg/kg]	Mg_{LE} [mg/kg]	Fe_{LE} [mg/kg]	Mn_{LE} [mg/kg]	Zn_{West} [mg/kg]	Zn_{LE} [mg/kg]	Cu_{West} [mg/kg]	Cu_{LE} [mg/kg]	B_{LE} [mg/kg]	Mo_{LE} [mg/kg]	Na[mg/kg]	El. Conductivity [µS/cm, 25°C]	Al_{LE} [mg/kg]
2	1	0.09	-	72.1	-	5.0	224	144	360	20,285	857	2,770	138	222	-	2.88	-	11.22	-	-	-	-	192
36	1	0.09	-	210.2	-	30.1	121	435	733	23,021	414	1,738	190	354	-	4.25	-	12.56	-	-	-	-	155
36	2	0.03	16.57	302.3	270.1	41.3	142	360	708	22,079	494	1,850	182	319	-	4.65	-	13.36	-	-	-	-	155
152	1	0.11	-	97.0	-	19.0	799	467	870	55,884	571	3,389	-	114	-	1.45	-	0.31	-	0.009	-	-	-
163	1	0.14	-	107.0	-	40.0	646	555	897	53,793	621	2,979	-	231	-	1.42	-	0.27	-	0.011	-	-	-
163	2	0.12	73.56	501.8	494.6	173.7	386	3,102	5,791	24,627	333	1,745	215	381	-	8.05	-	16.78	-	-	-	-	153
163	3	0.15	12.70	168.2	34.6	41.5	1,217	726	1,065	55,577	736	3,420	1	273	8.75	2.56	7.31	4.26	10.71	0.027	2,617	1,864	42
205	1	0.06	-	89.3	-	21.3	482	452	760	56,236	478	1,977	198	157	-	3.58	-	3.59	-	0.008	-	-	61
205	2	0.06	4.23	140.6	132.2	12.8	693	184	465	22,486	559	2,442	148	292	-	2.21	-	6.81	-	-	-	-	165
205	3	0.08	9.63	105.7	81.4	29.3	303	544	745	54,487	462	1,720	124	148	7.54	2.20	12.67	5.08	3.25	0.021	715	529	61
241	1	0.13	-	203.5	-	75.5	1,102	736	1,339	23,003	616	1,843	118	343	-	7.55	-	6.35	-	0.022	-	-	116
241	2	0.05	2.70	142.7	133.8	14.8	924	319	631	23,419	803	2,561	141	321	-	2.14	-	7.77	-	-	-	-	157
241	3	0.03	3.53	89.8	80.8	6.1	280	371	645	24,423	756	2,742	94	225	6.95	1.27	6.79	8.26	2.89	0.008	477	306	151
256	1	0.19	-	138.0	-	32.0	1,074	529	920	55,032	543	3,245	-	123	-	0.57	-	0.22	-	-	-	-	-
258	1	0.04	-	105.9	-	8.6	376	234	460	18,342	475	1,409	187	290	-	3.25	-	10.59	-	-	-	-	175
266	1	0.13	-	90.0	-	15.0	508	489	860	53,449	690	3,401	-	251	-	3.01	-	1.38	-	-	-	-	8
266	2	0.17	75.05	586.6	530.4	193.4	305	3,995	5,113	25,668	326	1,759	155	404	-	9.73	-	18.90	-	-	-	-	67
266	3	0.15	5.80	115.6	-	49.3	1,282	442	784	58,015	615	3,713	-	104	0.00	-	0.33	-	8.00	0.042	1,454	1,166	-
266	3	0.16	3.41	113.7	3.8	40.1	1,992	513	791	56,678	819	4,002	-	109	0.20	-	0.43	-	8.91	0.069	1,491	2,167	-
266	3	0.18	7.26	145.3	5.8	56.9	1,914	537	870	58,068	796	3,822	-	116	0.21	-	0.41	-	8.63	0.059	2,399	2,197	-
273	2	0.13	71.03	492.4	488.9	164.6	336	2,823	5,085	25,228	333	1,732	155	388	-	8.10	-	15.61	-	-	-	-	75
273	3	0.07	10.04	141.1	6.9	36.8	1,397	733	1,035	56,293	616	3,116	-	227	4.90	1.30	5.38	1.25	9.82	0.039	1,362	1,083	16
273	3	0.07	10.04	141.1	6.9	36.8	1,397	733	1,035	56,293	616	3,116	-	227	4.90	1.30	5.38	1.25	9.82	0.039	1,362	1,083	16
273	3	0.07	10.04	141.1	6.9	36.8	1,397	733	1,035	56,293	616	3,116	-	227	4.90	1.30	5.38	1.25	9.82	0.039	1,362	1,083	16
292	1	0.16	-	56.7	-	32.9	1,144	297	635	61,967	662	1,676	-	49	-	0.34	-	0.26	-	0.011	-	-	-
292	2	0.06	1.71	96.4	92.8	7.3	2,093	219	566	21,272	1,103	3,088	167	245	-	1.59	-	6.95	-	-	-	-	192
292	3	0.09	7.10	62.0	-	46.6	739	325	464	58,284	601	1,326	-	86	6.32	-	9.26	-	2.32	0.016	1,212	1,460	-
308	1	0.13	-	84.0	-	14.0	482	468	840	54,466	884	3,370	-	274	-	2.88	-	5.90	-	-	-	-	26
308	2	0.16	77.59	518.5	507.0	177.6	357	3,739	5,892	24,726	317	1,735	164	387	-	8.11	-	14.96	-	-	-	-	67
308	3	0.13	5.61	121.9	-	23.2	1,163	647	957	52,905	925	3,842	-	207	5.62	0.87	4.06	-	6.53	0.040	2,179	1,548	-
311	1	0.20	-	273.2	-	95.1	737	880	1,153	23,775	750	1,966	122	318	-	7.96	-	6.93	-	0.016	-	-	118
311	2	0.03	1.74	96.2	96.5	6.8	2,257	224	553	21,153	672	3,068	163	242	-	3.82	-	8.45	-	-	-	-	194
318	1	0.25	-	664.1	-	294.5	691	1,206	2,000	25,260	507	1,846	142	294	-	20.18	-	7.69	-	0.021	-	-	72

Farm no.	Year	N_{total} [%]	P_{H2O} [mg/kg]	P_{CAL} [mg/kg]	P_{LE} [mg/kg]	P_{Olsen} [mg/kg]	S_{LE} [mg/kg]	K_{CAL} [mg/kg]	K_{LE} [mg/kg]	Ca_{LE} [mg/kg]	$Mg_{Schacht}$ [mg/kg]	Mg_{LE} [mg/kg]	Fe_{LE} [mg/kg]	Mn_{LE} [mg/kg]	Zn_{West} [mg/kg]	Zn_{LE} [mg/kg]	Cu_{West} [mg/kg]	Cu_{LE} [mg/kg]	B_{LE} [mg/kg]	Mo_{LE} [mg/kg]	Na[mg/kg]	El. Conductivity [µS/cm, 25°C]	Al_{LE} [mg/kg]
318	2	0.04	2.05	91.0	71.3	7.0	942	258	605	27,717	638	2,687	151	343	-	4.92	-	8.54	-	-	-	-	181
444	1	0.22	-	251.5	-	100.6	596	879	1,208	23,651	923	1,968	117	324	-	9.00	-	11.75	-	0.022	-	-	117
457	1	0.02	-	134.4	-	14.0	401	222	370	28,494	354	1,126	131	124	-	3.01	-	2.68	-	0.021	-	-	65
488	1	0.12	-	159.6	-	30.6	190	383	803	37,238	721	3,169	127	456	-	5.13	-	10.96	-	0.003	-	-	132
488	2	0.06	3.00	96.6	97.8	5.2	507	330	675	23,604	531	2,314	207	281	-	35.14	-	6.84	-	-	-	-	150
488	3	0.03	7.71	98.2	95.1	14.9	146	303	515	19,628	667	2,429	103	255	7.72	1.24	4.37	8.08	2.25	0.006	532	288	163
541	1	0.21	-	329.0	-	93.0	345	940	1,810	41,026	724	2,778	154	316	-	7.34	-	10.79	-	0.017	-	-	77
541	2	0.15	76.06	502.8	506.6	184.9	374	3,397	5,912	24,798	307	1,739	166	367	-	8.30	-	17.67	-	-	-	-	70
613	1	0.03	-	127.4	-	15.0	372	229	403	29,062	391	1,199	126	138	-	2.97	-	10.04	-	0.022	-	-	72
666	1	0.04	-	111.3	-	24.7	189	285	582	24,086	563	2,636	135	283	-	1.98	-	7.92	-	-	-	-	187
676	1	0.15	-	209.1	-	57.7	227	512	939	33,400	666	2,907	115	422	-	5.55	-	9.83	-	0.007	-	-	100
677	1	0.03	-	92.3	-	8.9	186	228	515	26,483	605	2,643	127	292	-	1.81	-	12.43	-	-	-	-	168
677	1	0.03	-	92.3	-	8.9	186	228	515	26,483	605	2,643	127	292	-	1.81	-	12.43	-	-	-	-	168
677	3	0.05	5.43	75.9	64.6	7.5	145	352	621	28,169	692	2,640	120	351	7.99	1.53	10.96	8.79	3.36	0.009	588	309	171
679	1	0.10	-	38.6	-	14.2	253	268	518	11,987	949	2,831	284	128	-	2.41	-	13.78	-	-	-	-	201
679	2	0.05	2.64	88.0	69.2	11.3	764	196	475	25,004	592	2,233	201	378	-	3.99	-	11.99	-	-	-	-	161
679	3	0.08	9.88	68.8	58.0	29.9	152	312	545	11,232	828	2,462	325	103	8.71	2.81	13.69	22.63	3.36	0.004	765	498	231
680	1	0.11	-	55.2	-	23.5	252	371	637	12,491	882	2,784	305	79	-	3.42	-	12.66	-	-	-	-	204
680	2	0.07	2.68	88.2	68.2	11.3	715	183	470	23,311	584	2,251	192	345	-	3.25	-	10.43	-	-	-	-	153
680	3	0.08	4.78	64.1	54.0	25.0	297	331	593	10,763	934	2,546	280	103	16.61	2.40	26.13	22.66	3.52	0.004	1,444	1,043	196
682	2	0.11	45.04	473.4	443.9	129.3	213	3,134	3,063	23,438	381	1,678	144	359	-	7.28	-	15.40	-	-	-	-	128
682	3	0.13	6.90	134.5	-	58.5	1,020	664	974	57,776	711	3,303	-	92	0.20	-	0.39	-	5.86	0.042	1,124	1,607	-
683	1	0.06	-	160.0	-	51.0	1,307	442	762	50,596	523	2,357	111	326	-	3.28	-	6.41	-	0.020	-	-	86
683	3	0.08	9.63	115.6	-	25.4	444	636	960	54,768	611	3,371	-	181	3.77	-	2.54	-	7.05	0.026	763	482	-
685	1	0.12	-	189.0	-	23.0	785	269	475	38,672	466	1,819	72	284	-	3.83	-	5.80	-	0.014	-	-	84
685	2	0.00	3.55	70.3	71.7	13.4	1,806	339	519	22,474	252	1,085	77	98	-	1.20	-	2.55	-	-	-	-	62
685	3	0.13	10.04	134.5	-	44.1	1,090	637	938	55,258	896	3,973	-	122	0.30	-	0.42	-	7.01	0.040	2,392	1,764	-
686	1	0.12	-	137.0	-	33.0	720	681	997	57,117	524	2,561	-	137	-	0.43	-	0.21	-	0.010	-	-	-
686	2	0.02	3.98	110.6	101.3	24.0	4,759	486	744	28,732	496	2,502	192	186	-	2.75	-	6.03	-	-	-	-	111
688	1	0.15	-	235.0	-	69.0	722	842	1,223	17,441	1,040	3,374	423	164	-	8.72	-	20.37	-	-	-	-	199
688	2	0.16	69.98	518.5	479.4	187.2	349	4,307	4,889	25,548	303	1,745	153	398	-	9.40	-	15.32	-	-	-	-	74
688	3	0.09	9.41	113.7	-	48.5	573	544	829	56,958	559	3,134	-	98	0.23	-	0.42	-	6.36	0.027	819	642	-
689	1	0.13	-	216.0	-	35.0	583	347	665	45,443	610	2,366	169	322	-	3.95	-	13.49	-	0.030	-	-	133
689	3	0.09	4.39	81.1	-	13.9	737	492	779	53,434	726	3,992	-	151	1.99	-	0.70	-	6.83	0.027	1,108	838	-
690	1	0.13	-	130.0	-	32.0	867	730	1,099	59,221	583	2,630	-	137	-	0.45	-	0.19	-	0.007	-	-	-

Farm no.	Year	N_{total} [%]	P_{H2O} [mg/kg]	P_{CAL} [mg/kg]	P_{LE} [mg/kg]	P_{Olsen} [mg/kg]	S_{LE} [mg/kg]	K_{CAL} [mg/kg]	K_{LE} [mg/kg]	Ca_{LE} [mg/kg]	$Mg_{Schacht}$ [mg/kg]	Mg_{LE} [mg/kg]	Fe_{LE} [mg/kg]	Mn_{LE} [mg/kg]	Zn_{West} [mg/kg]	Zn_{LE} [mg/kg]	Cu_{West} [mg/kg]	Cu_{LE} [mg/kg]	B_{LE} [mg/kg]	Mo_{LE} [mg/kg]	Na[mg/kg]	El. Conductivity [µS/cm, 25°C]	Al_{LE} [mg/kg]
690	2	0.14	58.66	490.2	461.9	144.6	323	2,834	4,360	24,205	356	1,711	165	392	-	7.61	-	21.26	-	-	-	-	92
692	1	0.09	-	145.4	-	15.7	235	318	618	22,554	648	2,143	163	285	-	2.57	-	11.19	-	-	-	-	213
692	2	0.09	1.20	131.5	100.8	13.7	523	333	663	24,594	991	2,844	175	349	-	2.90	-	11.74	-	-	-	-	164
692	3	0.07	14.66	177.2	161.6	40.1	302	296	563	22,011	696	2,297	132	320	8.40	2.06	11.72	13.55	2.28	0.007	402	339	173
692	3	0.08	7.77	169.2	210.1	34.7	491	484	970	25,474	647	2,216	166	435	10.89	2.81	14.07	19.49	2.14	0.011	425	611	183
692	3	0.11	16.82	290.4	286.6	88.3	1,286	436	726	24,027	885	2,291	188	381	10.77	3.75	14.37	16.18	2.84	0.010	753	1,234	158
694	2	0.05	4.58	100.6	77.5	15.2	641	230	524	25,612	535	2,120	187	401	-	1.52	-	14.19	-	-	-	-	154
696	2	0.06	3.45	167.9	186.1	16.8	458	222	457	17,008	441	1,443	144	309	-	1.87	-	12.40	-	-	-	-	137
696	3	0.08	11.97	168.2	212.9	25.4	159	573	807	13,711	446	1,261	93	247	13.55	2.55	15.49	11.14	2.37	0.007	251	281	104
696	3	0.05	3.33	84.8	110.6	8.5	242	162	346	13,627	530	1,408	171	213	10.71	1.44	13.36	12.61	1.64	0.010	439	363	163
710	1	0.17	-	219.0	-	63.0	651	809	1,184	16,277	1,178	3,589	378	219	-	7.50	-	14.39	-	0.009	-	-	216
710	2	0.14	6.04	201.8	19.3	62.4	2,770	1,480	1,677	57,812	652	3,159	-	195	6.35	1.40	1.95	-	10.40	0.035	1,897	3,280	-
710	3	0.09	7.84	129.9	132.4	21.5	277	294	527	17,179	601	1,752	118	321	12.54	2.23	14.07	13.01	2.47	0.007	518	419	146
712	3	0.13	9.47	142.2	-	46.8	1,172	593	848	55,205	865	4,013	-	116	0.33	-	0.44	-	7.07	0.029	2,221	1,717	-
721	2	0.15	5.77	191.7	13.2	66.6	2,670	1,399	1,727	57,750	663	3,290	-	139	2.03	-	0.72	-	10.69	0.045	2,242	3,570	-
721	3	0.08	8.16	134.1	133.9	21.9	325	342	560	17,589	596	1,747	120	349	14.33	3.20	13.73	13.35	2.53	0.008	622	498	138
724	1	0.08	-	117.0	-	43.0	8,761	796	1,314	33,693	791	3,522	279	214	-	5.93	-	3.57	-	0.200	-	-	106
724	2	0.15	2.84	141.1	7.2	37.4	2,909	758	992	58,572	753	3,677	-	91	0.17	-	0.40	-	14.42	0.061	3,561	4,000	-
724	3	0.13	6.66	108.5	106.4	18.7	102	342	534	17,979	606	1,790	127	278	13.79	3.17	13.98	15.19	2.19	0.008	210	208	143
725	1	0.12	-	160.0	-	25.0	262	245	601	47,583	648	2,661	190	268	-	3.20	-	14.57	-	0.010	-	-	144
725	2	0.13	2.53	139.0	7.2	37.6	2,909	740	977	59,129	746	3,784	-	98	0.26	-	0.56	-	14.87	0.051	3,521	4,490	-
725	3	0.13	6.66	111.4	113.2	19.6	106	338	567	18,344	595	1,862	125	315	16.72	3.21	13.95	15.03	2.17	0.007	202	203	146
726	2	0.12	2.84	145.0	6.9	40.0	2,980	709	923	58,965	747	3,707	-	93	0.21	-	0.44	-	14.30	0.044	3,426	4,500	-
726	3	0.13	6.32	109.3	107.8	18.7	102	340	558	17,752	614	1,813	123	301	14.65	3.07	14.12	15.19	2.19	0.007	203	203	146
727	1	0.22	-	328.0	-	96.0	581	754	1,583	24,041	870	2,711	308	318	-	10.36	-	13.95	-	0.011	-	-	157
727	3	0.07	7.79	123.6	130.9	19.4	303	351	609	18,249	599	1,824	131	331	13.42	2.49	14.47	14.11	2.53	0.008	814	599	144
728	1	0.41	-	489.0	-	150.0	1,963	1,292	2,279	26,281	741	1,769	440	261	-	80.61	-	27.38	-	0.299	-	-	100
728	2	0.12	4.71	171.8	11.3	56.7	2,700	1,286	1,660	59,884	702	3,430	-	128	0.44	-	0.52	-	12.15	0.043	2,590	3,880	-
728	3	0.13	6.66	106.8	109.5	19.6	104	342	552	17,314	608	1,789	128	304	13.96	3.21	14.05	14.43	2.16	0.008	203	203	140
729	1	0.02	-	99.6	-	33.6	8,741	700	1,254	34,496	478	3,807	280	211	-	5.91	-	2.87	-	0.219	-	-	114
729	2	0.12	2.49	146.9	6.2	36.8	2,929	740	948	58,030	774	3,576	-	96	0.32	-	0.61	-	14.84	0.043	3,536	4,460	-
729	3	0.10	8.53	127.8	139.5	22.7	277	364	615	17,885	571	1,788	142	330	12.84	2.54	14.09	13.80	2.64	0.009	615	450	140
732	1	0.02	-	161.0	-	43.0	10,241	701	1,281	31,311	674	3,813	278	181	-	4.49	-	3.61	-	0.330	-	-	121
732	2	0.16	59.61	450.4	478.3	162.2	375	3,118	3,874	24,925	434	1,713	114	372	21.76	7.53	15.86	19.46	4.63	0.038	528	539	101
732	3	0.12	5.49	110.0	115.8	18.8	102	338	569	17,591	615	1,831	136	356	14.07	3.25	14.21	14.57	2.20	0.011	202	205	148

Farm no.	Year	N_{total} [%]	P_{H2O} [mg/kg]	P_{CAL} [mg/kg]	P_{LE} [mg/kg]	P_{Olsen} [mg/kg]	S_{LE} [mg/kg]	K_{CAL} [mg/kg]	K_{LE} [mg/kg]	Ca_{LE} [mg/kg]	$Mg_{Schacht}$ [mg/kg]	Mg_{LE} [mg/kg]	Fe_{LE} [mg/kg]	Mn_{LE} [mg/kg]	Zn_{West} [mg/kg]	Zn_{LE} [mg/kg]	Cu_{West} [mg/kg]	Cu_{LE} [mg/kg]	B_{LE} [mg/kg]	Mo_{LE} [mg/kg]	Na[mg/kg]	El. Conductivity [µS/cm, 25°C]	Al_{LE} [mg/kg]
733	1	0.18	-	293.0	-	78.0	412	998	1,997	42,280	674	2,900	134	310	-	6.73	-	11.97	-	0.012	-	-	80
734	1	0.08	-	198.0	-	26.0	627	307	676	51,144	706	2,958	182	285	-	4.31	-	11.51	-	0.016	-	-	136
734	2	0.05	14.09	445.3	473.4	41.1	204	458	912	21,516	399	1,634	154	372	-	5.60	-	14.24	-	-	-	-	204
735	1	0.03	-	97.0	-	10.0	847	510	850	49,621	703	3,770	107	250	-	2.08	-	8.06	-	0.028	-	-	97
735	2	0.00	3.70	68.2	74.8	13.0	2,022	317	485	21,409	271	1,106	81	98	-	1.24	-	2.43	-	-	-	-	61
736	2	0.10	15.86	453.7	473.1	42.9	143	517	1,029	21,929	478	1,665	155	375	-	5.25	-	16.69	-	-	-	-	203
736	3	0.08	15.21	207.4	188.5	79.8	1,744	313	420	47,188	546	1,843	78	138	3.99	1.60	4.23	4.08	5.95	0.045	1,653	1,602	66
736	3	0.10	4.36	121.5	118.4	28.7	2,349	214	300	43,272	726	1,698	119	81	3.89	1.86	4.76	4.76	6.45	0.085	3,308	2,939	64
737	2	0.14	70.26	535.6	502.6	167.3	341	3,602	4,973	25,440	338	1,787	172	422	-	9.82	-	16.36	-	-	-	-	72
739	1	0.07	-	91.0	-	22.0	710	554	851	52,853	738	3,299	-	260	-	1.53	-	0.75	-	0.008	-	-	-
739	2	0.00	4.03	79.3	80.2	14.2	1,857	348	507	24,451	223	1,134	85	104	-	1.11	-	2.14	-	-	-	-	60
740	1	0.08	-	90.0	-	12.0	345	491	704	46,841	680	2,879	128	215	-	3.79	-	8.96	-	0.017	-	-	59
740	2	0.11	15.60	429.2	475.5	42.1	122	438	883	21,882	375	1,674	167	395	-	5.83	-	15.66	-	-	-	-	210
741	1	0.11	-	91.0	-	17.0	599	478	862	53,258	664	3,450	-	237	-	3.00	-	1.28	-	0.007	-	-	13
741	2	0.07	15.13	444.7	482.3	42.0	140	457	895	21,393	379	1,669	169	378	-	5.73	-	15.80	-	-	-	-	210
743	1	0.20	-	322.0	-	85.0	953	705	1,468	20,972	1,102	2,970	324	266	-	10.61	-	16.81	-	0.007	-	-	172
743	3	0.14	6.95	111.0	113.6	18.9	107	337	542	18,068	628	1,833	135	348	13.76	3.28	13.91	17.62	2.23	0.009	207	207	147
744	2	0.00	2.63	65.2	68.2	12.1	2,003	292	457	23,473	224	1,108	86	93	-	1.38	-	2.79	-	-	-	-	67
745	1	0.07	-	66.0	-	12.0	456	481	842	52,034	759	3,414	55	231	-	2.39	-	3.83	-	-	-	-	56
753	1	0.06	-	157.0	-	17.0	228	262	571	23,150	702	3,026	203	222	-	2.12	-	10.96	-	-	-	-	185
753	2	0.12	3.24	160.1	128.1	34.4	1,652	203	448	22,365	1,710	4,253	291	277	-	3.26	-	14.15	-	-	-	-	157
753	3	0.05	2.50	88.7	70.9	10.7	574	216	416	18,312	824	2,675	198	226	21.85	1.56	15.74	12.35	2.77	0.009	1,702	1,163	153
754	1	0.05	-	105.0	-	16.0	267	188	472	19,503	787	2,889	187	212	-	2.90	-	14.43	-	-	-	-	202
754	2	0.13	4.00	162.5	138.1	34.7	1,916	209	468	22,963	1,840	4,299	288	292	-	3.40	-	16.88	-	-	-	-	150
754	3	0.04	14.86	187.8	170.2	37.0	815	273	525	18,025	898	3,065	169	196	9.80	1.64	14.32	12.35	3.84	0.008	2,249	1,491	179
755	1	0.07	-	189.0	-	25.0	302	289	579	20,219	732	2,956	264	222	-	4.34	-	10.78	-	-	-	-	178
755	2	0.19	3.87	195.9	161.4	32.8	1,836	219	486	22,153	1,592	4,197	290	305	-	3.17	-	18.98	-	-	-	-	160
755	3	0.07	4.38	127.3	109.9	15.9	761	285	568	20,142	935	3,024	207	185	8.53	1.96	12.67	13.82	3.12	0.008	2,619	1,804	177
756	1	0.06	-	245.0	-	18.0	248	277	618	19,725	699	2,889	208	172	-	2.44	-	16.86	-	-	-	-	200
756	2	0.13	4.70	175.7	144.9	39.4	2,302	211	476	23,820	1,705	4,088	307	337	-	3.78	-	16.67	-	-	-	-	156
756	3	0.09	3.13	160.7	143.0	21.1	1,505	399	678	18,663	1,203	3,250	205	195	9.26	2.29	13.95	13.23	4.16	0.008	3,703	2,861	183
757	1	0.11	-	169.0	-	35.0	715	237	511	23,121	697	3,056	284	332	-	2.96	-	21.30	-	-	-	-	187
757	2	0.24	4.08	219.2	197.7	30.7	1,654	244	523	19,954	1,476	3,991	293	230	-	2.84	-	17.19	-	-	-	-	176
757	3	0.04	12.75	172.2	151.3	30.7	504	313	617	23,116	757	3,002	200	236	9.51	1.95	13.66	16.50	3.62	0.008	1,629	1,000	175
758	2	0.13	4.05	185.8	161.4	33.0	1,743	251	528	22,265	1,367	3,979	342	236	-	4.13	-	17.64	-	-	-	-	160

Farm no.	Year	N_{total} [%]	P_{H2O} [mg/kg]	P_{CAL} [mg/kg]	P_{LE} [mg/kg]	P_{Olsen} [mg/kg]	S_{LE} [mg/kg]	K_{CAL} [mg/kg]	K_{LE} [mg/kg]	Ca_{LE} [mg/kg]	$Mg_{Schacht}$ [mg/kg]	Mg_{LE} [mg/kg]	Fe_{LE} [mg/kg]	Mn_{LE} [mg/kg]	Zn_{West} [mg/kg]	Zn_{LE} [mg/kg]	Cu_{West} [mg/kg]	Cu_{LE} [mg/kg]	B_{LE} [mg/kg]	Mo_{LE} [mg/kg]	Na[mg/kg]	El. Conductivity [µS/cm, 25°C]	Al_{LE} [mg/kg]
758	3	0.02	4.09	147.9	133.7	20.0	671	249	491	22,354	983	3,263	161	255	9.02	2.22	14.02	12.84	3.32	0.007	2,442	1,773	184
759	1	0.23	-	97.0	-	14.0	260	300	535	9,993	949	2,354	135	105	-	2.91	-	9.73	-	-	-	-	188
759	2	0.05	3.53	94.6	89.7	11.9	566	278	529	12,963	1,037	2,934	189	72	-	1.68	-	9.69	-	-	-	-	197
759	3	0.03	8.13	97.9	107.4	19.5	42	304	546	8,492	666	1,995	158	32	8.54	1.12	13.28	9.83	1.76	0.003	175	140	226
760	1	0.09	-	106.0	-	15.0	1,007	308	611	13,446	860	2,567	162	99	-	2.32	-	11.74	-	-	-	-	215
760	2	0.06	5.65	116.5	108.1	20.1	606	285	549	13,257	912	2,795	182	80	-	1.53	-	9.81	-	-	-	-	178
760	3	-	4.45	-	78.2	-	108	159	459	11,060	830	2,315	150	52	6.20	1.12	10.51	10.01	2.37	0.013	360	207	170
760	3	0.04	2.86	75.0	76.8	10.5	77	244	362	11,401	778	2,282	134	111	7.03	0.67	9.81	10.39	2.07	0.003	451	301	197
761	1	0.16	-	104.2	-	11.3	836	277	569	14,771	1,031	2,791	190	165	-	3.54	-	16.15	-	-	-	-	163
761	2	0.08	1.80	221.8	57.1	8.3	417	219	488	17,710	931	2,923	192	172	-	1.98	-	15.55	-	-	-	-	189
761	3	0.05	14.97	97.0	72.0	29.3	116	309	506	15,222	709	2,420	129	144	6.32	1.56	9.91	11.53	2.48	0.004	347	243	155
762	1	0.11	-	127.0	-	19.0	233	430	687	9,018	813	2,352	226	41	-	2.46	-	14.81	-	0.011	-	-	184
762	2	0.04	16.95	154.9	151.1	44.7	920	256	493	10,487	772	2,461	221	54	-	2.10	-	12.46	-	-	-	-	178
762	3	0.02	7.19	103.1	108.4	15.9	151	317	548	8,494	716	2,198	147	34	10.56	1.15	13.52	11.18	2.91	0.003	1,470	858	182
763	1	0.06	-	104.0	-	43.0	243	414	680	13,078	788	2,424	188	127	-	3.03	-	15.13	-	-	-	-	181
763	2	0.03	8.17	105.2	92.2	21.1	734	339	617	15,825	666	2,547	196	147	-	2.95	-	16.47	-	-	-	-	192
764	1	0.04	-	117.0	-	15.0	274	294	520	10,169	720	2,488	165	62	-	2.36	-	10.52	-	-	-	-	185
764	2	0.10	3.40	107.3	101.7	18.7	1,388	308	566	11,213	1,017	2,774	244	71	-	1.56	-	10.74	-	-	-	-	172
764	3	0.04	5.40	87.5	81.2	10.3	82	260	472	9,948	719	2,375	156	39	7.96	1.14	11.59	10.77	2.50	0.003	475	273	205
765	1	0.14	-	123.0	-	17.0	389	372	649	11,341	789	2,248	182	82	-	3.08	-	10.16	-	-	-	-	205
766	2	0.07	4.79	97.1	92.3	10.9	544	278	562	13,125	867	2,856	196	77	-	1.53	-	9.80	-	-	-	-	199
767	2	0.04	2.25	86.5	80.3	9.9	868	238	502	13,253	1,068	3,232	194	95	-	1.10	-	14.96	-	-	-	-	204
768	1	0.04	-	73.0	-	13.0	320	382	641	17,036	662	2,363	131	201	-	3.59	-	7.06	-	-	-	-	162
768	2	0.04	2.63	89.8	86.0	10.9	809	256	495	13,597	894	2,871	191	92	-	1.66	-	10.91	-	-	-	-	199
769	1	0.03	-	260.0	-	59.0	314	532	809	16,236	671	2,107	141	234	-	3.71	-	12.99	-	-	-	-	146
769	2	0.05	4.00	96.9	92.6	13.1	598	285	579	13,154	877	2,902	191	84	-	1.51	-	12.71	-	-	-	-	192
770	1	0.05	-	99.0	-	13.0	1,341	245	565	11,426	939	2,857	99	88	-	1.88	-	12.15	-	-	-	-	157
770	2	0.04	2.96	90.5	88.9	12.0	891	238	500	13,987	901	2,890	200	109	-	1.09	-	9.20	-	-	-	-	193
770	3	0.01	7.19	114.8	96.2	10.5	260	319	563	11,887	708	2,542	129	57	8.66	1.09	12.75	9.96	3.11	0.004	718	416	183
771	1	0.02	-	183.0	-	26.0	403	277	607	15,933	895	3,014	178	209	-	2.28	-	11.10	-	-	-	-	206
771	2	0.05	2.21	90.8	84.8	10.7	1,056	233	483	13,437	1,063	3,093	205	107	-	1.25	-	10.67	-	-	-	-	202
772	1	0.04	-	79.0	-	7.0	2,456	244	451	9,501	1,998	3,913	147	392	-	3.70	-	8.62	-	0.011	-	-	153
772	2	0.04	4.83	109.2	105.2	13.8	464	286	593	12,611	1,466	2,788	185	74	-	2.59	-	13.22	-	-	-	-	183
772	3	0.04	33.96	246.3	238.2	76.8	348	267	473	13,165	728	2,360	195	117	7.82	1.72	12.60	11.25	3.61	0.004	1,483	852	155
773	1	0.03	-	203.0	-	41.0	628	315	627	16,959	924	3,266	185	233	-	2.96	-	12.84	-	-	-	-	209

Farm no.	Year	N_{total} [%]	P_{H2O} [mg/kg]	P_{CAL} [mg/kg]	P_{LE} [mg/kg]	P_{Olsen} [mg/kg]	S_{LE} [mg/kg]	K_{CAL} [mg/kg]	K_{LE} [mg/kg]	Ca_{LE} [mg/kg]	$Mg_{Schacht}$ [mg/kg]	Mg_{LE} [mg/kg]	Fe_{LE} [mg/kg]	Mn_{LE} [mg/kg]	Zn_{West} [mg/kg]	Zn_{LE} [mg/kg]	Cu_{West} [mg/kg]	Cu_{LE} [mg/kg]	B_{LE} [mg/kg]	Mo_{LE} [mg/kg]	Na[mg/kg]	El. Conductivity [µS/cm, 25°C]	Al_{LE} [mg/kg]
773	3	0.03	10.72	256.7	275.5	29.2	506	260	482	14,567	810	2,676	172	177	9.91	1.33	12.03	10.53	4.07	0.005	1,860	1,388	172
774	1	0.06	-	102.0	-	16.0	201	219	512	17,569	703	2,688	199	163	-	3.08	-	16.43	-	-	-	-	172
774	2	0.06	4.08	168.4	143.5	35.9	2,030	210	473	22,535	1,690	4,161	305	352	-	3.23	-	14.56	-	-	-	-	166
775	1	0.08	-	155.0	-	28.0	394	238	512	18,897	704	2,851	235	228	-	2.75	-	13.51	-	-	-	-	179
775	2	0.14	3.35	200.8	167.1	30.7	1,939	225	501	22,407	1,401	3,997	313	323	-	3.08	-	13.69	-	-	-	-	173
775	3	0.08	9.45	98.4	96.1	23.8	343	256	474	12,741	726	2,260	276	84	8.78	1.92	12.31	14.73	3.29	0.004	1,176	704	179
776	1	0.09	-	172.0	-	29.0	365	242	522	21,088	761	2,999	274	244	-	2.68	-	16.23	-	-	-	-	192
776	2	0.07	4.28	198.7	194.1	34.5	1,661	278	543	20,632	1,890	3,930	369	292	-	3.39	-	11.56	-	-	-	-	174
776	3	0.01	8.39	183.8	170.2	23.1	988	382	629	15,594	944	3,164	150	143	10.50	1.82	14.70	11.30	3.96	0.005	2,743	1,845	215
777	1	0.02	-	99.4	-	28.4	8,482	922	927	29,821	440	2,979	216	153	-	5.09	-	2.63	-	0.140	-	-	94
777	2	0.10	3.55	169.5	142.4	31.5	1,618	207	487	22,457	1,454	4,336	304	344	-	2.99	-	19.04	-	-	-	-	169
778	1	0.07	-	124.9	-	17.1	393	256	517	20,580	445	1,645	153	298	-	2.78	-	10.55	-	-	-	-	167
784	2	0.12	5.53	186.8	20.3	63.2	2,600	1,359	1,667	57,921	714	3,140	-	190	2.94	0.79	0.72	-	11.16	0.040	2,258	3,490	3
784	3	0.12	6.35	111.0	113.6	18.3	108	337	558	17,469	624	1,876	147	358	14.17	3.54	14.43	14.20	2.19	0.010	206	208	148
785	1	0.10	-	145.0	-	40.0	746	639	982	56,690	655	2,644	-	119	-	0.56	-	0.27	-	0.013	-	-	-
785	2	0.13	2.80	141.7	12.4	38.5	2,800	693	961	59,277	753	3,475	-	122	0.23	-	0.50	-	14.49	0.046	2,830	3,980	-
785	3	0.09	7.26	243.0	133.2	16.9	206	287	533	18,085	570	1,826	136	400	12.17	2.47	13.64	13.07	2.43	0.010	520	372	152
786	1	0.16	-	295.0	-	90.0	538	661	1,411	19,977	898	3,019	367	302	-	8.90	-	17.44	-	0.005	-	-	179
786	2	0.12	4.55	178.4	21.9	54.8	2,630	1,207	1,469	59,560	686	3,032	-	173	1.30	0.44	0.59	-	10.50	0.037	1,690	3,270	2
786	3	0.14	6.90	107.9	117.1	17.4	107	337	558	17,608	630	1,887	153	386	13.52	3.66	13.98	13.73	2.29	0.010	204	203	145
787	2	0.10	2.63	138.3	12.7	35.7	2,853	680	874	59,355	691	3,331	-	118	0.00	-	0.33	-	13.63	0.041	2,729	3,860	-
787	3	0.13	7.06	113.4	120.4	19.2	108	341	572	17,378	620	1,855	133	303	10.27	3.38	16.07	14.09	2.21	0.008	203	204	143
788	1	0.12	-	273.0	-	62.0	788	821	1,180	18,515	1,287	3,419	388	276	-	27.23	-	14.36	-	0.010	-	-	195
788	2	0.12	5.90	212.0	33.3	76.1	2,806	1,613	1,901	58,408	632	3,103	-	223	14.05	2.64	14.40	-	9.98	0.032	2,017	3,290	6
788	3	0.14	5.32	101.2	100.4	16.0	97	342	559	17,971	602	1,935	117	302	6.99	2.72	2.41	12.58	1.97	0.009	204	200	130
789	2	0.11	6.57	202.4	16.9	76.1	2,594	1,803	2,149	58,152	643	3,180	-	131	12.99	-	14.14	-	10.84	0.041	2,199	3,510	3
789	3	0.14	6.14	107.5	114.7	18.5	105	346	575	18,185	581	1,833	123	337	1.16	2.99	0.61	13.97	2.11	0.010	202	204	143
790	2	0.19	70.38	480.0	511.3	190.2	483	3,926	4,474	26,521	400	1,756	108	367	12.67	7.02	14.15	17.33	4.83	0.040	621	650	80
790	3	0.08	7.19	127.3	129.7	17.9	208	318	537	17,112	545	1,672	105	325	13.95	2.14	14.83	12.28	2.12	0.008	479	375	135
6771	1	0.06	-	137.3	-	12.9	673	467	703	20,935	653	2,018	123	269	-	3.05	-	7.27	-	0.013	-	-	112
6771	3	0.05	6.30	74.7	60.1	10.3	254	503	793	27,150	746	2,625	137	314	7.52	1.75	9.90	9.33	3.21	0.011	1,019	618	156
6772	3	0.06	4.03	96.3	87.8	12.4	1,137	317	548	24,527	781	2,527	148	325	7.47	1.94	10.99	10.07	3.59	0.009	2,124	1,456	151
7821	1	0.13	-	57.1	-	23.1	221	242	460	14,267	808	2,660	282	112	-	2.87	-	14.78	-	-	-	-	178
7821	3	0.09	2.38	35.6	34.7	14.7	306	315	516	10,111	966	2,517	253	92	14.93	1.62	25.96	16.48	3.13	0.004	1,454	1,182	182
7822	3	0.08	2.13	41.8	29.5	21.0	512	259	483	14,611	781	2,485	281	174	12.14	1.41	19.50	15.73	4.06	0.004	1,622	943	194

Tab. 8.14: Results of chemical analysis of young, fully matured main stem leaves of organic cotton (*Gossypium barbadense*) in Egypt in 2008-2010.

Farm no.	Year	C [%]	N [%]l	P [g/kg]	S [g/kg]	K [g/kg]	Ca [g/kg]	Mg [g/kg]	Fe [mg/kg]	Mn [mg/kg]	Zn [mg/kg]	Cu [mg/kg]	B [mg/kg]	Mo [mg/kg]	Na [mgkg]
2	1	41.3	4.00	1.76	6.87	14.08	28.60	7.85	518	63.3	35.8	12.6	58.5	2.2	-
36	1	40.4	3.87	3.55	7.54	24.99	28.90	6.66	718	98.0	52.1	11.5	53.8	1.2	-
36	2	42.0	3.96	4.51	9.82	28.18	26.61	3.99	624	43.2	29.1	13.6	47.3	1.3	-
152	1	39.7	3.92	2.16	9.64	38.97	30.82	5.66	255	41.6	26.5	9.9	52.0	2.8	-
163	1	40.9	5.01	4.98	9.00	28.96	29.05	4.56	192	40.9	54.8	13.1	36.4	1.8	-
163	2	41.9	4.02	3.71	10.76	31.93	27.56	4.94	234	43.7	29.0	15.4	36.0	2.1	-
163	3	41.8	4.89	3.79	9.22	35.14	25.23	5.28	328	32.9	36.9	12.0	43.1	3.1	299
205	1	39.6	4.20	2.24	9.67	37.07	34.68	4.91	617	123.0	27.1	10.1	67.7	2.7	-
205	2	42.3	4.38	2.19	13.02	33.57	26.92	5.78	507	114.8	30.1	13.2	74.2	2.9	-
205	3	41.6	4.39	2.54	8.29	30.00	28.26	4.30	417	74.3	21.6	12.0	60.1	2.1	1,916
241	1	40.4	3.88	2.97	9.91	34.00	27.24	4.61	395	49.7	31.9	9.7	69.3	1.7	-
241	2	42.2	3.44	2.22	9.67	32.79	26.98	5.41	790	82.4	22.8	11.1	78.5	1.2	-
241	3	44.6	3.49	2.59	7.38	24.08	16.51	4.60	455	66.7	24.5	11.5	57.9	1.1	1,536
256	1	39.9	4.22	2.47	12.15	37.22	32.28	4.73	173	39.6	27.9	11.3	44.3	2.8	-
258	1	41.4	3.46	2.26	9.39	23.36	26.77	5.53	563	43.5	29.0	11.8	60.0	0.7	-
266	1	41.8	4.55	3.55	8.36	30.74	24.09	5.69	355	47.8	33.4	12.8	40.1	1.8	-
266	2	42.3	4.22	3.58	9.20	31.92	27.07	4.84	170	48.2	27.6	16.3	37.4	2.3	-
266	3	39.9	4.01	3.61	8.75	32.44	33.40	8.45	279	67.3	23.0	10.3	54.8	1.9	390
266	3	39.2	3.96	3.22	8.53	31.82	37.14	7.47	369	81.9	20.8	11.1	49.8	2.0	514
266	3	39.5	3.94	3.69	9.86	28.35	34.23	8.98	307	55.6	19.4	10.7	52.6	2.1	334
273	2	42.1	3.84	3.46	10.13	31.95	27.67	5.15	169	38.5	27.9	14.5	35.7	2.1	-
273	3	39.9	4.56	2.61	10.38	39.76	29.42	6.62	349	48.7	23.7	12.0	51.8	2.8	449
273	3	42.5	4.95	3.80	9.49	29.61	27.04	7.49	296	68.0	25.5	11.1	54.0	2.0	557
273	3	41.2	4.91	3.40	9.68	29.73	27.97	6.24	303	47.4	24.4	11.1	51.4	3.4	510
292	1	40.2	3.84	1.54	9.58	18.43	33.12	5.45	507	49.6	24.5	8.3	68.1	3.1	-
292	2	41.0	4.05	1.71	12.16	39.47	27.18	6.61	574	109.1	25.5	11.8	91.3	3.0	-
292	3	40.5	4.50	2.22	9.91	16.55	40.86	7.97	544	73.9	25.4	13.1	79.7	2.8	4,341
308	1	41.7	4.57	3.20	9.16	26.82	27.76	4.89	249	58.6	31.2	13.7	35.5	3.0	-
308	2	41.2	4.14	3.10	10.12	36.97	31.83	5.52	241	52.6	26.1	15.0	40.8	2.4	-
308	3	41.9	5.25	4.25	10.93	37.91	28.64	7.46	363	52.4	26.4	11.3	45.2	2.7	387
311	1	40.5	3.99	1.55	9.73	31.61	25.99	5.24	767	100.2	20.4	9.3	72.7	2.3	-
311	2	41.7	4.37	1.81	11.77	32.35	25.75	6.37	537	88.2	27.4	12.3	84.5	2.8	-
318	1	40.5	3.92	2.24	9.75	33.39	27.30	4.53	533	70.2	26.2	9.3	72.0	1.9	-
318	2	42.7	3.73	1.76	9.47	29.66	25.08	5.64	505	97.6	20.6	10.6	82.0	1.5	-
444	1	40.8	3.90	2.75	9.30	34.08	25.72	4.63	440	46.5	31.9	9.6	70.3	1.5	-
457	1	39.8	3.48	1.42	7.88	34.60	24.17	5.40	735	76.7	21.1	9.1	60.8	1.8	-
488	1	40.4	4.13	2.92	10.97	34.39	28.53	4.67	445	56.0	31.3	9.7	76.2	1.9	-
488	2	43.3	4.14	1.74	8.97	33.92	18.57	5.40	519	110.8	22.9	12.1	77.9	1.7	-

Farm no.	Year	C [%]	N [%]l	P [g/kg]	S [g/kg]	K [g/kg]	Ca [g/kg]	Mg [g/kg]	Fe [mg/kg]	Mn [mg/kg]	Zn [mg/kg]	Cu [mg/kg]	B [mg/kg]	Mo [mg/kg]	Na [mgkg]
488	3	43.1	4.40	3.41	9.51	24.13	20.77	5.25	582	80.0	56.9	11.9	55.6	1.8	1,908
541	1	40.5	5.09	4.42	8.19	31.33	30.93	4.99	192	41.6	44.5	12.0	37.6	1.8	-
541	2	40.3	4.17	2.90	10.95	43.75	34.83	6.37	217	51.5	24.7	17.4	46.7	2.3	-
613	1	40.6	3.83	2.61	9.87	34.49	25.35	4.73	429	66.2	25.7	8.6	72.3	1.8	-
666	1	40.7	3.12	2.23	8.07	29.64	23.93	4.77	644	73.9	25.0	8.0	74.2	1.0	-
676	1	38.4	4.13	2.41	14.81	35.21	40.49	5.60	774	133.3	30.1	10.2	74.7	3.1	-
677	1	40.0	3.97	2.81	12.86	37.38	29.82	6.12	540	143.1	25.3	9.1	83.5	1.6	-
677	1	40.0	3.97	2.81	12.86	37.38	29.82	6.12	540	143.1	25.3	9.1	83.5	1.6	-
677	3	40.8	4.45	2.88	10.17	31.75	23.66	5.75	710	107.6	27.6	12.6	67.3	3.0	4,210
679	1	42.0	4.42	3.45	5.70	31.45	18.92	5.16	376	32.5	25.2	9.4	37.3	1.2	-
679	2	42.5	4.15	4.95	10.24	25.43	28.05	4.61	1,049	69.9	35.8	14.9	61.9	0.9	-
679	3	41.5	2.68	4.35	9.91	21.98	26.17	5.14	461	28.6	26.0	9.9	45.5	0.9	474
680	1	41.6	4.51	3.93	7.03	31.33	20.74	5.11	171	20.1	29.5	10.2	36.1	1.6	-
680	2	43.0	4.17	3.98	9.22	25.31	26.66	5.44	929	81.7	34.0	14.2	60.1	1.2	-
680	3	41.6	2.89	4.11	8.52	19.64	23.40	5.05	1,046	38.1	28.8	11.5	42.9	0.9	443
682	2	41.4	4.16	3.13	10.43	35.78	31.36	5.65	212	49.1	27.8	17.8	41.3	2.4	-
682	3	41.1	3.55	2.69	7.36	23.02	32.84	6.47	524	104.1	20.3	9.0	40.9	1.7	314
683	1	38.2	3.44	3.58	12.77	37.39	43.40	4.83	490	80.6	37.2	12.4	55.1	1.2	-
683	3	41.3	4.73	3.29	10.50	31.35	29.76	5.67	294	71.9	30.4	12.2	45.5	3.8	377
685	1	39.9	3.82	2.10	9.39	31.97	37.07	6.94	333	69.4	25.6	7.3	79.5	1.7	-
685	2	41.2	4.26	2.91	9.84	38.17	30.96	5.19	202	53.7	28.4	17.7	43.4	2.4	-
685	3	42.0	5.20	4.27	9.49	35.82	25.47	6.66	390	54.2	27.8	12.3	45.7	2.6	453
686	1	39.5	4.25	3.16	8.51	34.40	32.40	7.28	299	93.1	34.8	10.0	52.5	1.8	-
686	2	42.3	4.43	3.18	9.52	30.15	26.37	6.15	188	80.1	29.4	14.3	41.2	1.8	-
688	1	40.9	4.27	3.42	8.69	35.32	24.84	5.57	261	49.7	33.3	11.0	39.5	1.7	-
688	2	42.0	4.24	3.26	9.61	34.24	28.27	4.89	211	52.7	30.5	17.7	39.5	2.4	-
688	3	41.8	4.25	3.24	8.30	27.51	23.92	4.76	344	55.2	23.1	11.4	38.0	1.9	291
689	1	40.0	4.87	4.35	11.03	33.29	35.13	6.36	279	45.9	39.7	13.2	49.2	2.0	-
689	3	41.5	4.79	3.19	9.09	32.92	24.95	5.62	330	63.5	30.1	12.9	37.2	2.5	276
690	1	39.8	4.28	3.49	8.95	34.77	32.68	7.04	249	90.9	39.8	10.4	51.3	1.5	-
690	2	42.7	4.42	3.27	9.19	30.12	25.00	5.34	193	56.2	30.3	17.1	37.2	2.3	-
692	1	41.4	4.04	1.80	7.33	26.12	22.62	5.46	499	56.2	36.5	11.9	57.4	1.6	-
692	2	42.7	4.40	2.77	8.00	28.60	25.88	5.90	423	75.4	26.8	14.0	59.4	1.5	-
692	3	42.6	4.38	3.26	9.20	21.09	29.59	6.56	326	63.9	25.3	13.5	50.1	1.3	236
692	3	42.5	4.40	2.79	8.78	20.38	29.02	5.51	343	58.4	28.0	13.1	49.2	1.4	190
692	3	43.2	4.45	3.74	8.01	18.07	25.34	5.48	414	56.5	27.3	12.9	46.4	1.2	210
694	2	42.7	4.09	2.60	7.34	27.36	23.39	5.67	578	56.5	23.2	13.0	60.3	1.6	-
696	2	42.7	3.94	2.97	7.81	22.59	29.82	6.01	462	55.5	28.2	14.6	49.2	0.8	-
696	3	44.1	3.34	2.67	5.77	14.16	18.73	4.85	331	29.9	27.0	11.7	37.2	0.6	170
696	3	43.6	3.98	3.86	6.86	18.32	21.02	3.96	346	41.8	31.3	17.4	41.3	1.1	185
710	1	40.2	4.13	3.88	7.18	47.63	14.19	6.66	180	30.0	22.9	12.4	45.3	2.2	-

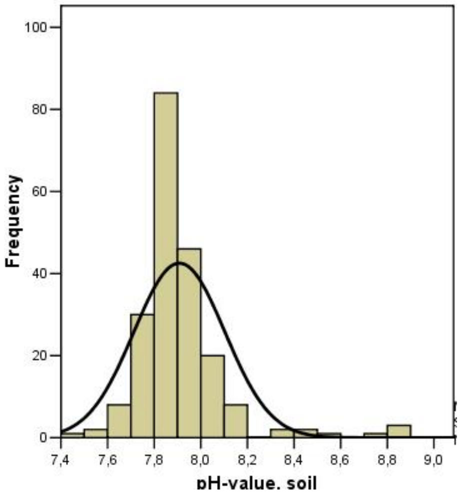
Farm no.	Year	C [%]	N [%]l	P [g/kg]	S [g/kg]	K [g/kg]	Ca [g/kg]	Mg [g/kg]	Fe [mg/kg]	Mn [mg/kg]	Zn [mg/kg]	Cu [mg/kg]	B [mg/kg]	Mo [mg/kg]	Na [mgkg]
710	2	40.9	3.84	3.07	8.90	32.27	29.78	4.74	415	52.4	27.2	12.3	46.2	2.7	488
710	3	40.4	4.40	3.15	9.23	38.19	28.41	6.79	222	70.9	27.3	13.0	44.5	3.0	323
712	3	40.6	4.66	3.35	8.52	38.40	25.17	6.60	330	81.9	31.6	14.2	43.2	2.6	297
721	2	40.0	4.03	3.08	8.71	43.87	31.78	5.92	287	50.5	23.5	10.3	71.8	3.3	647
721	3	40.3	4.59	2.98	9.57	39.68	28.36	7.07	223	65.6	28.0	13.3	48.4	3.3	318
724	1	42.4	3.05	5.27	7.47	29.95	18.24	4.47	134	26.9	31.3	7.6	28.7	0.7	-
724	2	39.6	3.45	2.35	8.94	38.03	40.13	5.30	572	45.2	19.8	12.8	56.9	3.5	698
724	3	40.0	4.41	2.90	9.14	45.55	27.59	6.88	287	70.2	33.7	13.1	48.4	3.0	385
725	1	41.1	3.80	4.66	7.92	54.86	14.87	7.36	163	33.2	30.0	10.5	48.2	2.2	-
725	2	39.0	3.26	2.18	9.60	40.26	44.59	5.46	672	49.4	19.6	12.8	66.0	3.6	777
725	3	40.8	4.51	2.78	9.04	41.43	28.49	6.38	413	76.4	28.3	13.4	48.6	3.2	338
726	2	40.7	4.00	3.35	10.68	35.29	33.99	5.42	436	53.8	27.9	12.9	51.5	2.9	636
726	3	39.9	4.27	2.79	9.55	40.25	30.89	6.96	229	83.9	27.2	12.8	48.5	3.2	356
727	1	40.8	4.49	3.85	8.11	30.99	20.57	7.70	1,074	43.0	33.2	11.5	37.0	0.7	-
727	3	40.4	4.33	3.04	8.82	38.26	27.65	6.90	234	79.2	28.4	12.5	45.0	3.1	313
728	1	41.2	3.93	4.79	10.40	30.31	24.70	4.58	652	45.4	47.4	11.7	36.5	1.4	-
728	2	40.6	3.76	2.71	8.17	33.51	33.59	5.45	327	37.4	17.4	11.0	43.4	2.9	386
728	3	40.3	4.45	2.87	10.13	37.33	29.26	6.84	231	67.3	32.1	12.9	44.9	3.3	361
729	1	41.0	4.75	3.85	7.71	30.01	20.85	7.60	1,182	46.7	32.3	17.7	37.0	0.7	-
729	2	40.8	3.70	2.52	8.87	29.39	32.74	5.01	412	50.9	23.0	11.9	36.0	2.3	318
729	3	40.8	4.52	3.19	9.01	36.96	27.10	6.70	213	69.5	32.5	13.0	44.9	3.2	337
732	1	41.2	4.60	4.28	8.04	41.65	14.58	6.89	142	36.5	28.9	12.0	44.7	1.0	-
732	2	40.6	3.99	3.12	10.26	32.44	34.94	5.34	374	52.4	26.1	13.3	51.8	2.8	504
732	3	40.0	4.50	2.86	9.98	41.01	29.51	7.08	229	67.4	26.9	12.7	46.4	3.2	328
733	1	41.8	3.57	4.70	9.23	29.68	22.99	4.85	343	42.8	34.1	11.4	34.2	1.0	-
734	1	40.9	4.91	4.52	8.83	29.26	29.07	4.63	202	44.3	35.6	12.0	37.1	1.6	-
734	2	40.7	4.31	2.85	9.76	39.69	31.59	5.47	187	51.3	27.2	17.0	43.0	2.5	-
735	1	42.5	3.19	5.16	6.89	29.76	17.59	4.97	135	29.6	32.9	7.8	28.5	0.6	-
735	2	42.7	4.30	3.37	8.64	32.84	25.35	4.63	166	48.2	27.2	17.7	36.9	2.3	-
736	2	42.7	4.53	3.70	9.69	29.19	25.16	5.84	200	58.5	31.2	13.6	37.6	2.1	-
736	3	42.1	4.28	2.86	7.49	25.26	25.54	5.56	342	24.7	22.3	12.4	48.1	2.3	299
736	3	41.6	4.70	2.94	8.60	27.47	29.47	5.83	440	34.0	33.9	13.0	49.4	2.3	361
737	2	42.6	4.58	3.46	9.32	29.82	25.67	6.26	217	62.2	29.6	15.2	41.6	2.1	-
739	1	41.7	3.80	3.60	8.67	32.70	23.22	5.28	298	49.6	36.5	10.6	39.2	1.5	-
739	2	41.7	4.45	3.55	10.45	34.55	28.65	5.73	222	60.8	29.0	17.1	40.8	2.3	-
740	1	40.1	4.01	3.59	7.89	34.78	31.01	6.20	317	95.0	25.7	9.9	45.0	1.6	-
740	2	40.7	3.96	2.83	10.70	39.72	33.63	5.58	186	56.5	26.0	17.5	43.9	2.4	-
741	1	41.9	3.67	4.15	8.64	29.98	23.54	5.31	359	52.3	33.5	13.2	34.0	1.1	-
741	2	41.3	4.26	3.00	9.47	37.29	31.16	5.32	194	53.0	26.9	14.9	41.5	2.6	-
743	1	41.4	4.29	4.20	7.68	41.46	14.22	6.54	130	33.1	24.6	8.9	41.0	1.3	-
743	3	40.7	4.48	3.11	8.15	38.61	26.11	7.05	226	75.7	32.4	13.7	43.7	3.1	312

Farm no.	Year	C [%]	N [%]l	P [g/kg]	S [g/kg]	K [g/kg]	Ca [g/kg]	Mg [g/kg]	Fe [mg/kg]	Mn [mg/kg]	Zn [mg/kg]	Cu [mg/kg]	B [mg/kg]	Mo [mg/kg]	Na [mgkg]
744	2	41.9	4.55	3.55	10.72	31.34	28.48	6.84	249	79.3	30.1	14.0	47.3	2.0	-
745	1	41.2	3.48	4.95	9.56	32.50	25.12	5.03	386	46.0	34.4	11.7	38.5	1.1	-
753	1	41.8	4.66	3.36	7.97	27.17	27.62	6.22	254	47.8	27.3	11.1	51.0	1.8	-
753	2	44.2	3.57	3.12	6.62	24.48	18.64	4.86	620	47.1	22.4	11.2	38.6	0.8	-
753	3	41.9	4.78	3.02	7.03	25.50	27.19	6.19	295	43.5	26.8	13.2	43.2	1.4	196
754	1	41.8	4.15	3.22	6.30	22.60	25.42	6.43	213	39.3	23.0	8.8	49.1	0.8	-
754	2	44.5	3.48	3.20	6.08	22.45	16.33	4.86	490	42.0	19.8	9.6	33.2	0.8	-
754	3	40.5	4.91	3.40	8.48	27.20	33.17	9.10	281	45.7	25.4	14.2	69.6	1.9	1,271
755	1	41.8	4.30	2.70	7.86	24.71	24.50	5.80	245	30.8	26.1	9.0	39.2	1.3	-
755	2	42.9	4.58	4.95	6.68	20.14	22.12	5.94	1,675	61.1	35.7	14.3	45.8	1.3	-
755	3	39.4	4.70	3.01	10.93	30.55	40.95	9.50	383	47.1	25.4	13.6	72.5	1.7	750
756	1	41.5	4.67	3.85	8.75	25.51	25.90	6.35	249	43.3	30.6	9.4	45.8	1.4	-
756	2	43.3	4.23	4.59	6.62	21.38	21.02	5.80	1,488	59.2	32.9	13.5	44.8	1.1	-
756	3	40.1	4.80	3.59	11.09	32.67	35.60	8.43	235	63.0	27.0	12.0	66.4	1.9	574
757	1	41.2	4.66	4.09	7.26	26.01	27.13	6.76	219	30.4	23.6	9.8	49.7	1.7	-
757	2	41.1	4.35	5.29	7.39	23.17	22.79	5.82	821	48.3	37.0	13.7	43.5	1.2	-
757	3	41.6	5.43	3.37	6.24	27.32	25.81	6.45	608	40.5	24.6	12.8	42.0	1.7	561
758	2	42.9	4.79	5.02	6.64	20.92	23.28	6.27	1,409	55.1	36.6	14.1	48.7	1.5	-
758	3	41.0	5.25	3.82	10.00	22.85	34.87	7.48	246	82.3	83.6	12.7	55.0	2.7	487
759	1	42.1	4.10	3.26	7.18	23.08	23.14	5.13	669	64.9	23.4	9.0	39.6	0.8	-
759	2	43.4	3.42	2.70	7.27	22.85	18.83	5.83	1,414	59.0	21.3	10.4	39.2	1.1	-
759	3	39.6	3.59	2.38	7.02	35.70	45.93	6.56	511	80.5	18.3	11.7	78.2	1.0	668
760	1	42.1	4.35	3.71	7.40	23.47	24.75	4.53	405	54.1	28.2	9.9	37.9	1.0	-
760	2	43.1	3.53	2.92	8.91	29.73	24.50	5.87	535	53.3	23.2	10.8	47.9	1.0	-
760	3	40.5	4.10	2.88	9.61	29.27	20.87	5.35	169	94.4	28.1	12.0	59.6	1.0	4,447
760	3	40.5	4.10	2.49	8.48	38.61	37.07	7.18	395	70.9	19.5	13.7	57.6	2.0	419
761	1	42.4	4.32	3.37	7.41	22.70	24.20	4.85	330	46.0	25.7	13.3	38.6	1.0	-
761	2	44.1	3.57	3.83	6.94	21.14	19.93	5.46	343	45.5	26.1	11.0	41.0	0.7	-
761	3	42.4	4.06	3.60	6.76	22.80	25.07	6.50	618	71.2	25.0	11.4	47.4	1.4	270
762	1	41.6	4.49	3.75	6.86	37.09	22.05	6.85	371	56.9	23.7	9.2	49.4	1.9	-
762	2	43.8	4.30	4.50	6.96	21.05	23.95	5.70	472	70.9	59.7	13.6	43.3	0.9	-
762	3	42.5	4.45	3.85	6.15	30.84	21.01	6.03	430	72.1	17.6	10.8	44.3	1.1	288
763	1	42.4	4.61	3.67	7.30	22.30	24.94	5.18	513	51.0	26.9	10.4	37.3	0.7	-
763	2	43.7	4.01	3.66	6.05	23.99	19.54	5.58	1,055	52.3	26.0	10.5	45.5	1.5	-
764	1	41.4	3.98	3.49	8.89	25.38	25.63	5.65	398	87.9	29.0	9.0	42.8	1.5	-
764	2	43.2	3.65	3.96	7.10	20.09	20.79	5.32	1,276	62.0	24.8	13.7	40.4	0.8	-
764	3	42.6	4.25	3.79	6.82	23.34	23.30	6.04	368	66.9	26.3	17.2	45.4	1.9	228
765	1	43.0	4.99	4.19	7.07	17.79	25.61	5.78	273	47.1	24.9	9.4	38.1	1.0	-
766	2	43.9	3.24	2.87	7.87	22.31	19.32	5.85	403	44.1	20.6	9.3	38.3	0.8	-
767	2	44.1	3.56	2.96	7.95	22.78	19.81	5.96	474	47.6	19.3	9.8	39.0	0.8	-
768	1	42.3	3.84	1.72	5.23	21.85	21.03	4.03	280	44.3	15.9	7.0	38.6	1.8	-

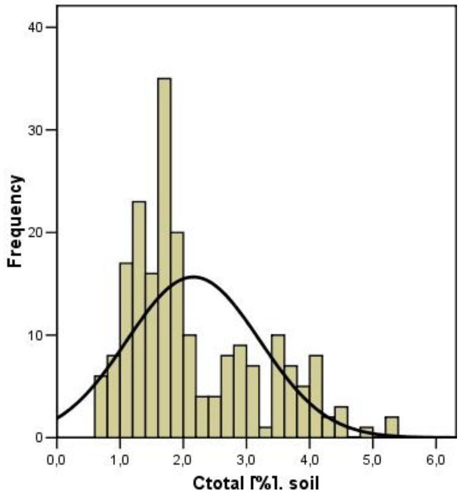
Farm no.	Year	C [%]	N [%]l	P [g/kg]	S [g/kg]	K [g/kg]	Ca [g/kg]	Mg [g/kg]	Fe [mg/kg]	Mn [mg/kg]	Zn [mg/kg]	Cu [mg/kg]	B [mg/kg]	Mo [mg/kg]	Na [mgkg]
768	2	41.6	3.15	2.86	7.77	22.50	20.00	6.14	2,846	80.7	26.1	12.8	41.8	0.7	-
769	1	40.4	3.65	3.71	11.63	31.59	33.53	5.40	550	66.9	26.5	8.3	51.0	1.3	-
769	2	44.1	3.40	3.02	7.20	21.54	18.86	5.44	419	44.7	22.6	11.6	35.0	0.8	-
770	1	42.1	4.14	3.76	6.55	25.00	22.90	5.46	286	70.5	19.1	9.5	37.8	1.6	-
770	2	44.0	3.35	2.89	7.70	21.67	19.34	5.30	467	45.4	22.5	11.7	37.0	0.8	-
770	3	44.8	4.33	5.47	6.31	14.13	16.52	3.87	1,064	72.1	33.1	13.6	30.8	2.1	429
771	1	41.6	4.18	4.16	7.75	27.21	25.42	5.93	281	77.6	19.3	9.4	37.3	1.5	-
771	2	44.0	3.41	3.36	6.59	22.96	19.04	4.78	622	46.2	25.7	12.6	37.6	0.8	-
772	1	41.8	3.82	4.28	7.64	24.37	22.73	5.23	275	73.8	22.8	9.4	36.1	1.3	-
772	2	43.8	3.49	3.11	8.16	24.69	19.96	5.66	504	47.9	25.0	11.1	41.8	0.8	-
772	3	43.1	4.61	3.85	6.54	22.37	24.37	6.04	396	64.7	29.5	13.6	46.3	1.0	264
773	1	42.0	4.08	4.04	6.78	25.02	22.17	5.28	268	69.5	21.2	9.3	38.3	1.5	-
773	3	44.2	4.89	4.00	7.59	23.51	24.29	5.73	690	72.9	30.8	12.8	47.4	1.7	708
774	1	41.9	3.64	3.00	7.39	25.26	22.09	4.92	372	41.0	33.8	11.6	44.9	0.8	-
774	2	44.5	3.35	3.53	5.88	19.62	16.31	4.68	462	40.8	24.8	11.3	35.1	0.8	-
775	1	41.6	4.48	3.87	6.40	26.76	25.21	6.38	312	44.0	29.3	9.5	48.6	1.6	-
775	2	44.3	3.25	3.28	6.54	22.56	16.48	4.86	389	40.0	23.0	10.5	35.8	0.8	-
775	3	42.2	5.16	3.25	6.88	26.17	26.54	6.35	433	45.6	33.3	13.8	52.4	2.7	376
776	1	41.3	5.13	4.42	8.80	26.84	28.96	6.49	256	36.4	29.8	10.5	46.4	1.9	-
776	2	44.5	3.37	3.54	6.16	20.94	16.31	4.89	345	41.6	22.9	10.6	34.4	0.7	-
776	3	39.0	3.84	3.35	9.67	35.56	40.36	8.41	704	71.9	24.0	12.9	69.5	2.4	1,276
777	1	41.6	3.69	4.80	9.33	31.88	23.80	4.79	388	44.3	50.4	12.6	35.3	1.0	-
777	2	44.6	3.25	3.19	6.32	19.23	16.30	4.99	365	42.0	26.0	10.6	32.9	0.7	-
778	1	40.8	4.03	2.83	8.69	22.61	29.45	6.13	491	78.0	37.9	11.4	53.3	1.3	-
784	2	41.0	3.85	2.87	9.45	29.64	32.69	5.47	375	50.7	23.2	12.9	43.0	2.8	317
784	3	40.6	4.48	3.26	8.73	36.24	28.73	6.98	264	81.0	30.4	14.1	46.1	3.2	332
785	1	40.6	4.19	4.18	12.54	32.20	26.69	5.31	598	49.4	45.9	11.0	60.1	3.0	-
785	2	38.8	3.72	3.14	10.81	45.28	39.97	7.31	480	70.7	21.9	11.9	109.8	3.3	555
785	3	40.1	4.58	3.14	9.76	40.55	29.73	7.08	243	73.3	30.9	14.1	46.6	3.3	358
786	1	41.2	3.96	3.87	9.34	32.46	25.71	5.20	327	49.4	34.1	11.2	37.8	1.5	-
786	2	40.7	4.00	3.46	11.42	27.68	36.12	4.71	501	62.5	29.3	14.0	37.8	2.2	284
786	3	40.6	4.40	3.12	8.10	36.16	25.73	6.58	199	78.4	27.3	13.3	45.5	3.0	352
787	2	38.6	3.30	2.57	10.28	43.73	42.49	6.17	750	58.6	22.2	13.5	81.5	3.3	723
787	3	40.5	4.47	2.92	8.97	39.12	25.25	6.63	246	71.7	26.1	14.0	45.0	2.9	350
788	1	41.4	3.76	4.24	6.87	42.06	12.81	6.92	162	38.1	25.1	12.4	41.8	1.1	-
788	2	41.3	4.04	2.44	9.13	26.26	33.41	4.56	490	55.9	25.2	13.6	40.1	2.8	338
788	3	39.8	4.46	2.75	9.37	42.64	29.13	6.94	201	75.5	27.1	13.9	46.4	3.2	342
789	2	39.8	3.94	3.04	9.52	39.48	34.54	6.29	360	56.4	21.3	11.9	77.1	3.0	638
789	3	40.4	4.44	3.23	9.22	38.34	26.47	7.35	259	74.8	26.7	13.5	44.8	2.7	340
790	2	40.8	4.29	3.18	10.30	30.31	35.75	5.36	535	58.6	25.4	13.7	46.7	2.7	517
790	3	40.7	4.62	2.98	9.21	39.57	26.69	6.74	270	68.4	29.5	14.2	47.9	3.1	347

Farm no.	Year	C [%]	N [%]l	P [g/kg]	S [g/kg]	K [g/kg]	Ca [g/kg]	Mg [g/kg]	Fe [mg/kg]	Mn [mg/kg]	Zn [mg/kg]	Cu [mg/kg]	B [mg/kg]	Mo [mg/kg]	Na [mgkg]
6771	1	40.3	3.91	2.44	11.26	31.84	25.74	5.11	622	106.7	25.9	9.4	73.2	1.6	-
6771	3	41.7	4.51	-	11.09	35.68	24.96	5.33	1,062	165.3	95.7	20.9	75.6	2.1	4,902
6772	3	41.0	3.97	-	11.17	32.91	27.60	5.92	796	82.5	29.7	12.6	87.7	1.4	5,774
7821	3	42.0	2.92	4.06	8.84	18.54	23.07	4.92	523	29.4	25.8	11.0	37.7	1.0	357
7822	3	42.7	3.02	3.73	7.36	17.27	20.71	4.49	481	25.9	24.5	12.0	36.8	0.9	343

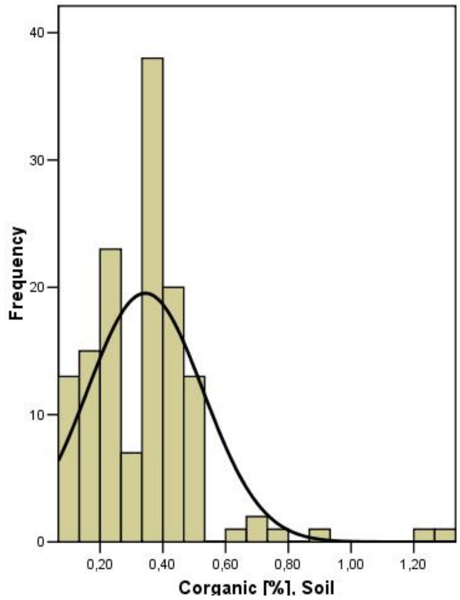
Fig. 8.1: Histogram of concentrations of nutrients and other attributes in Egyptian soils under organically grown cotton (*Gossypium barbandense*) between 2008 and 2010.



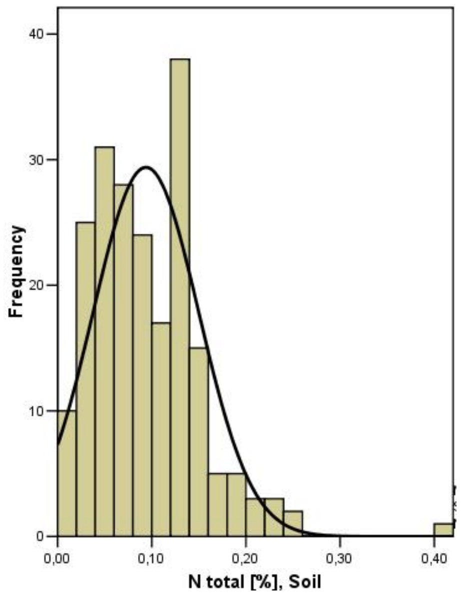
pH-value (DIN ISO 10390, 2005; VDLUFA, 2004b)



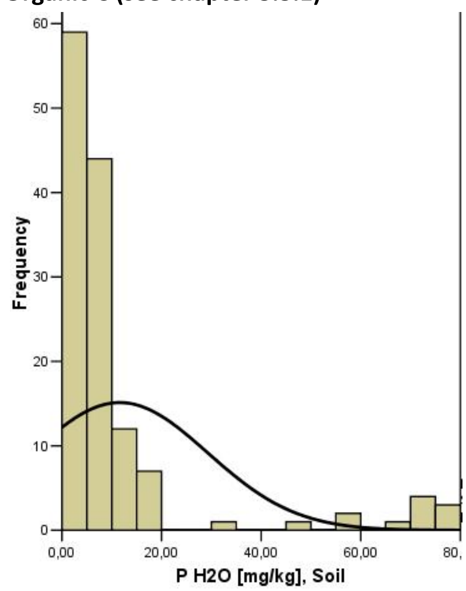
Total C (Elemental analyzer; vario MAX CNS)



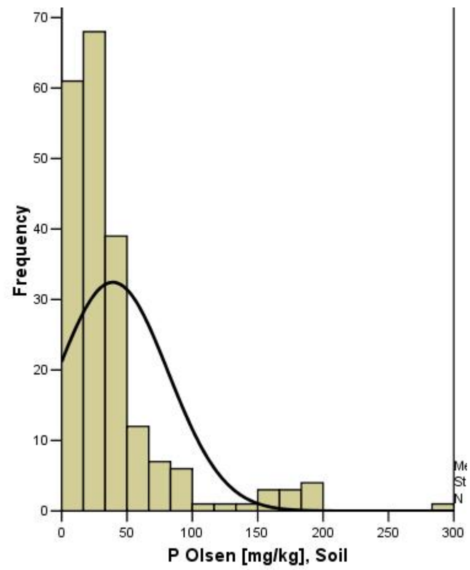
Organic C (see chapter 3.3.1)



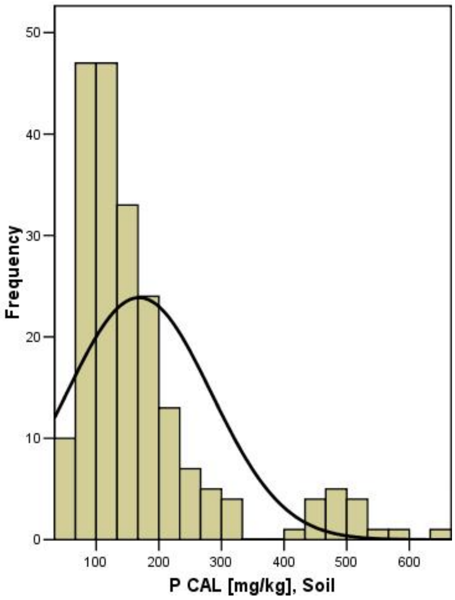
Total N (Elemental analyzer; vario MAX CNS)



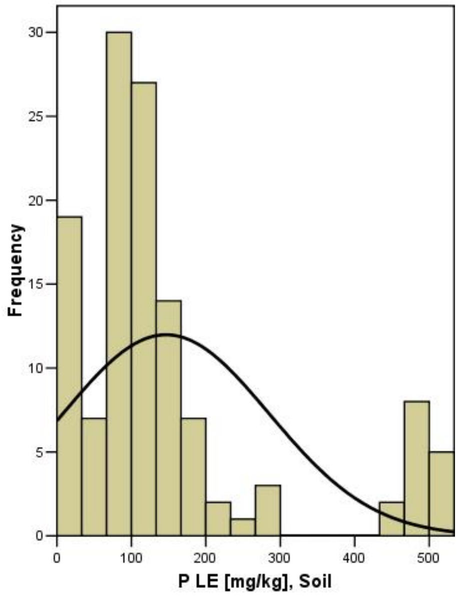
Water extractable P (Van der Paauw et al., 1971)



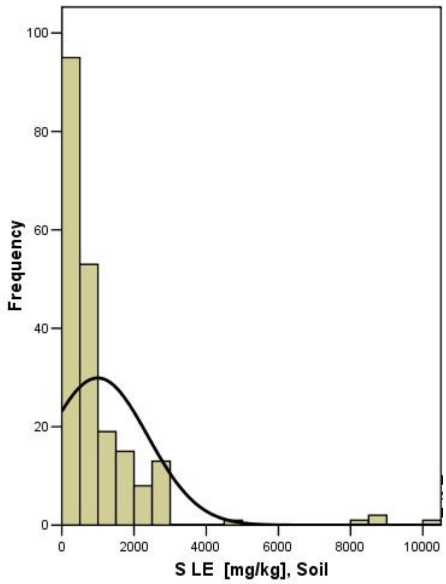
0.5 M $NaHCO_3$ extractable P (Olsen et al., 1954)



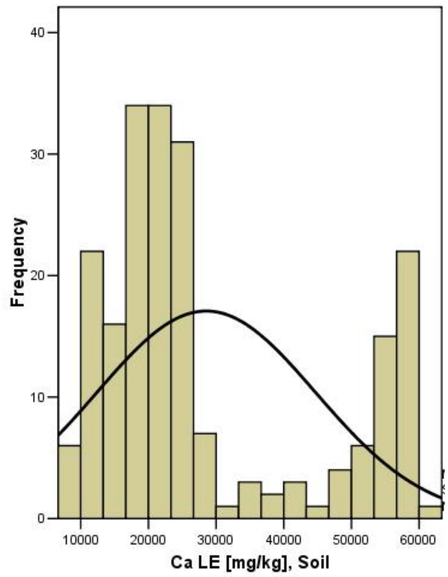
Calcium Acetate lactate (CAL)-extractable P (Schüller, 1969)



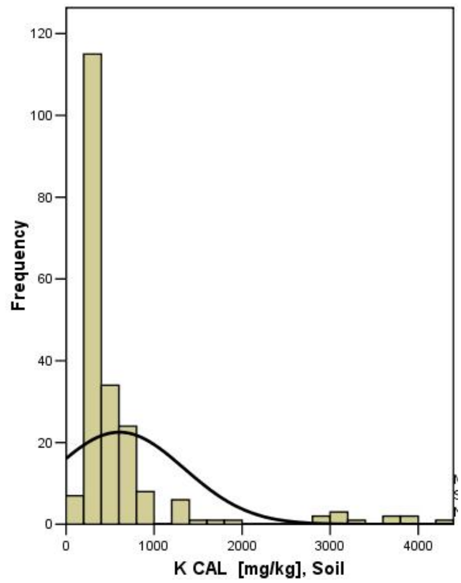
AAAc-EDTA-extractable P (Lakanen and Erviö, 1971)



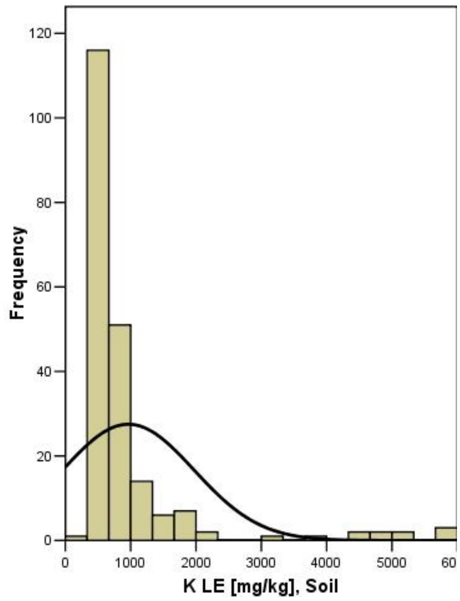
AAAc-EDTA-extractable S (Lakanen and Erviö, 1971)



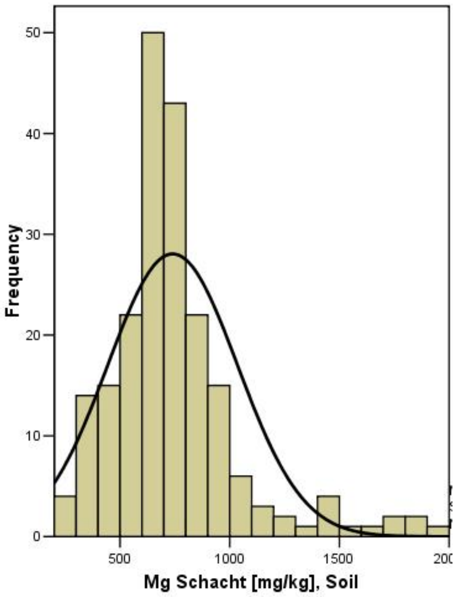
AAAc-EDTA-extractable Ca (Lakanen and Erviö, 1971)



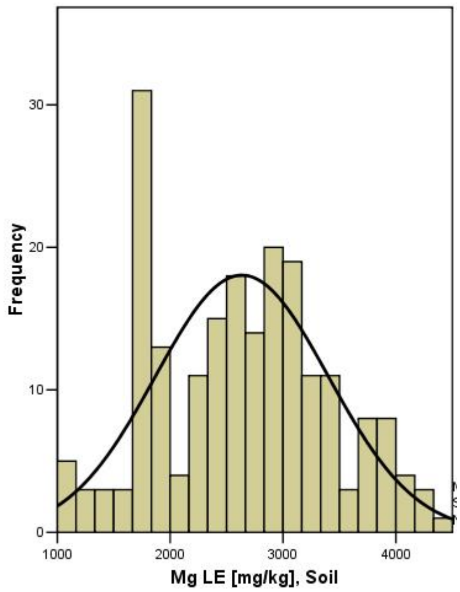
Calcium acetate lactate (CAL)-extractable K according to (Schüller, 1969)



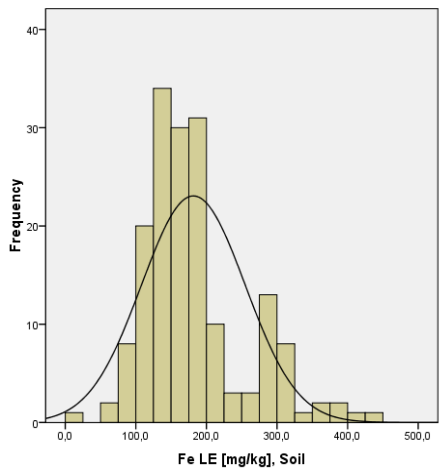
AAAc-EDTA-extractable K (Lakanen and Erviö, 1971)



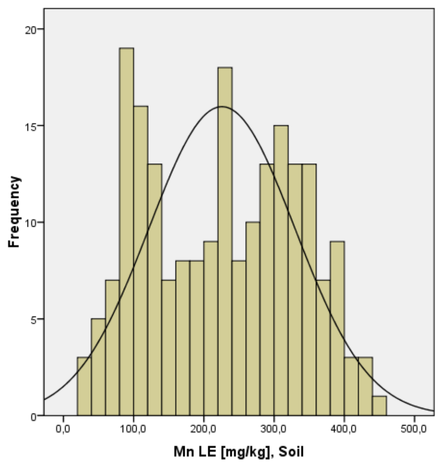
0.0125M $CaCl_2$-extractable Mg (Schachtschabel, 1954)



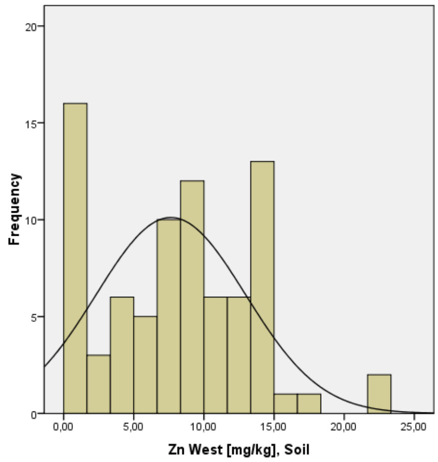
AAAc-EDTA-extractable Mg (Lakanen and Erviö, 1971)



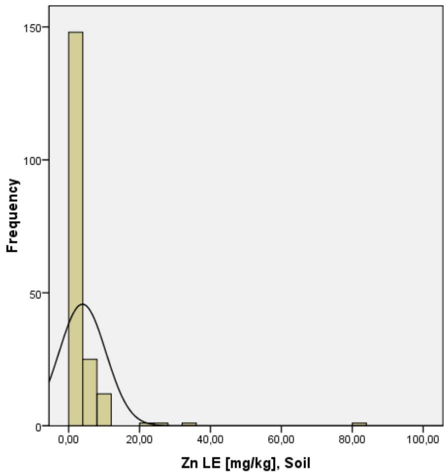
AAAc-EDTA-extractable Fe (Lakanen and Erviö, 1971)



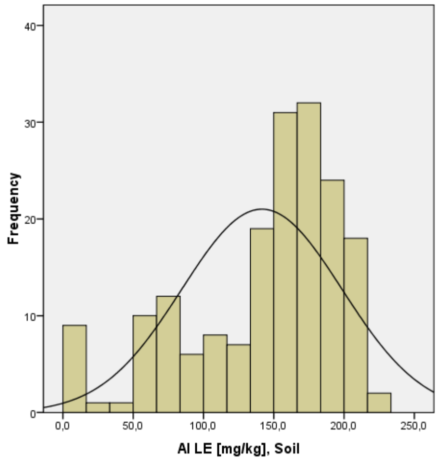
AAAc-EDTA-extractable Mg (Lakanen and Erviö, 1971)



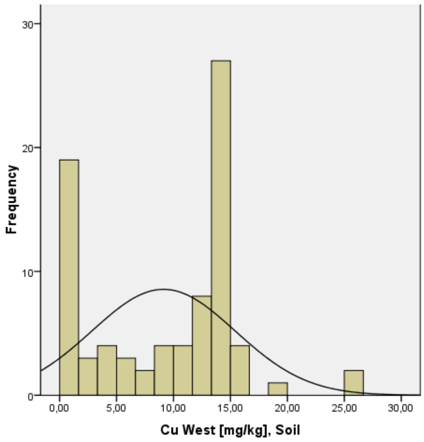
0.43 M HNO_3-extractable Zn (Haneklaus and Schnug, 1996)



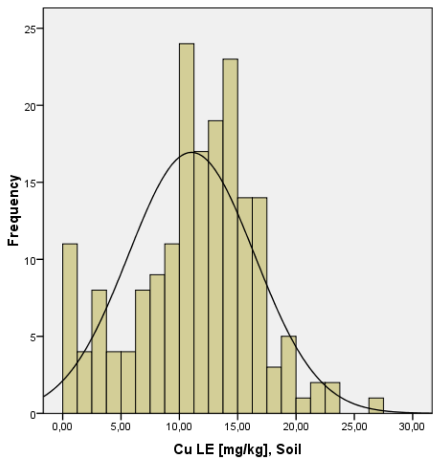
AAAc-EDTA-extractable Zn (Lakanen and Erviö, 1971)



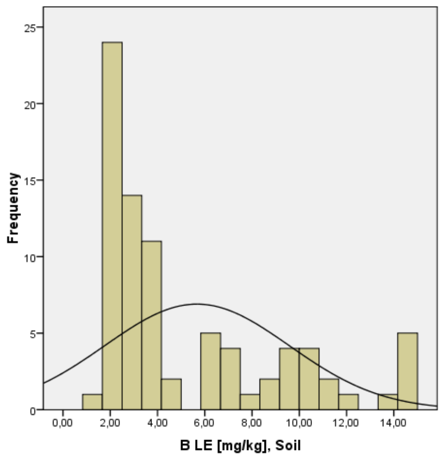
AAAc-EDTA-extractable Al (Lakanen and Erviö, 1971)



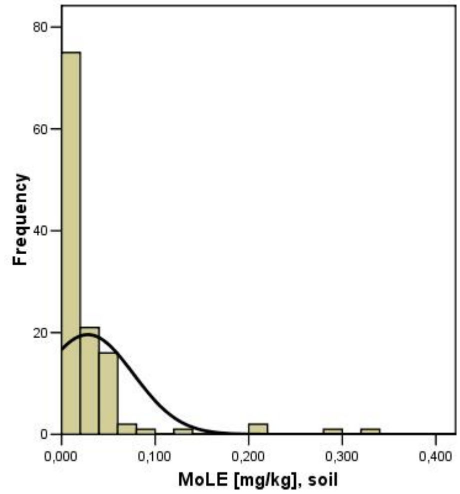
0.43 M HNO_3-extractable Cu (Haneklaus and Schnug, 1996)



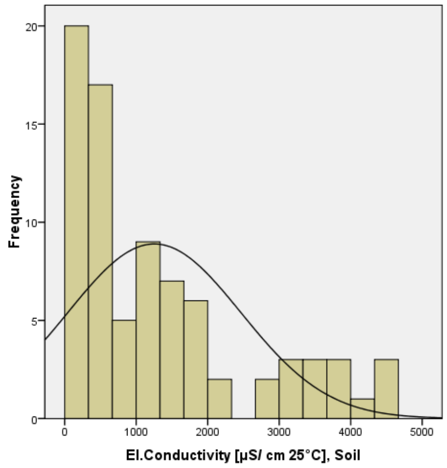
AAAc-EDTA-extractableCu (Lakanen and Erviö, 1971)



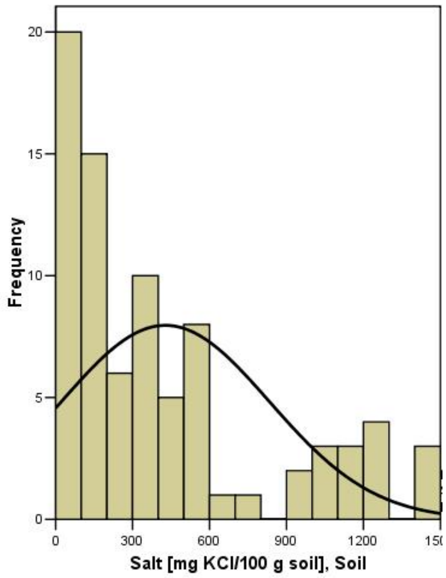
AAAc-EDTA-extractable B (Lakanen and Erviö, 1971)



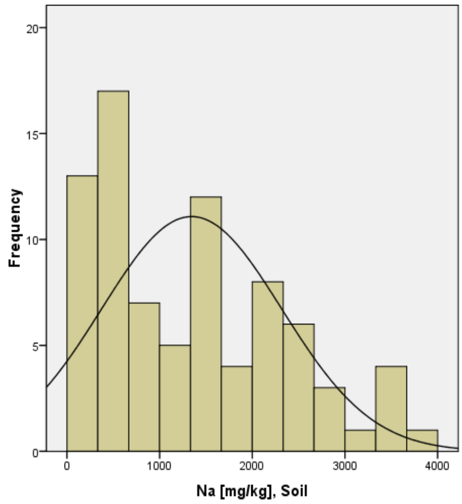
AAAc-EDTA-extractable Mo (Lakanen and Erviö, 1971)



Electrical conductivity (VDLUFA, 2009)

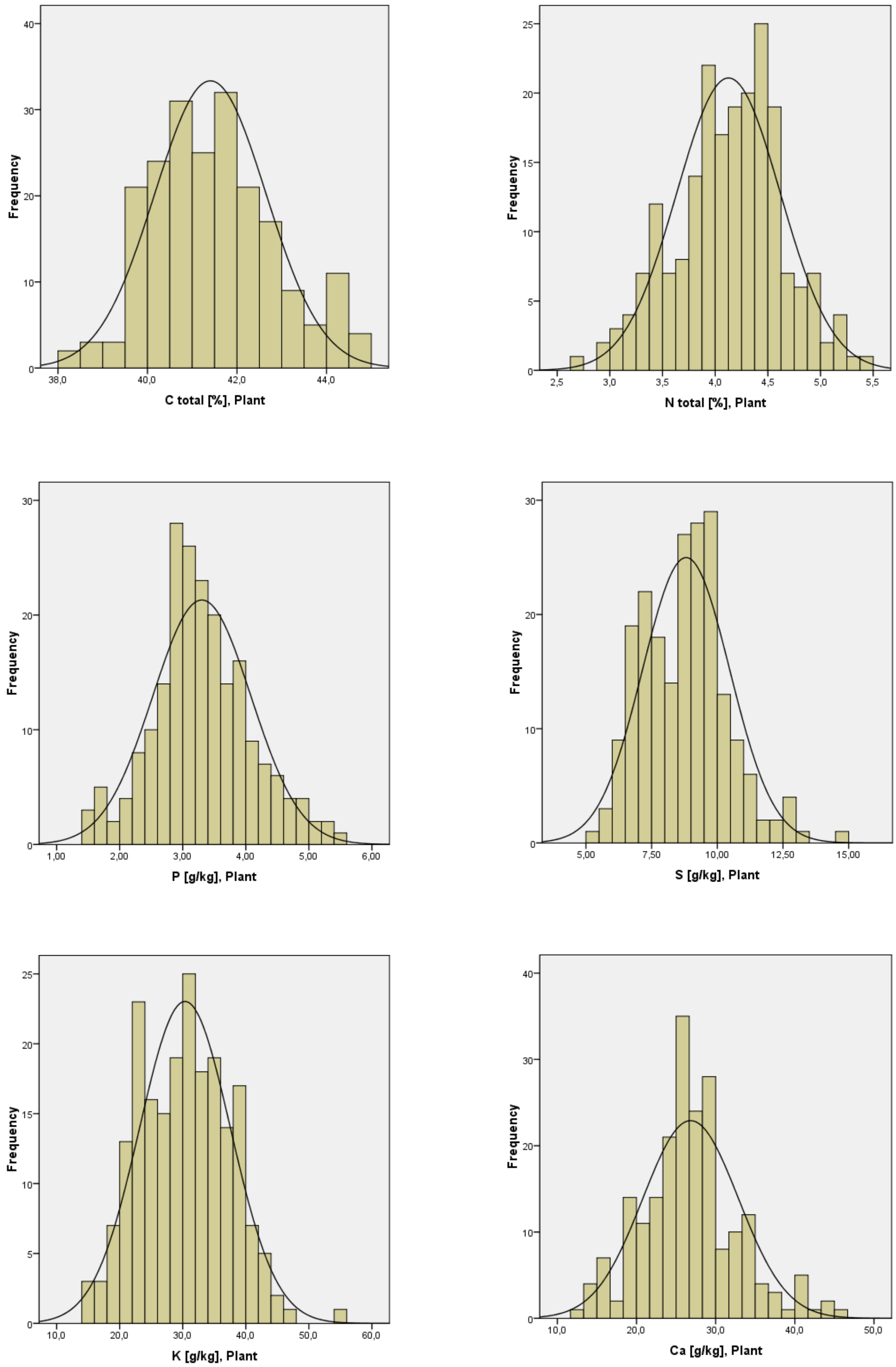


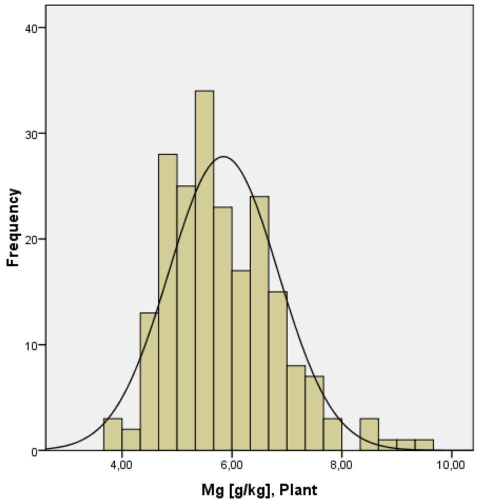
Salt concentration (VDLUFA, 2009)

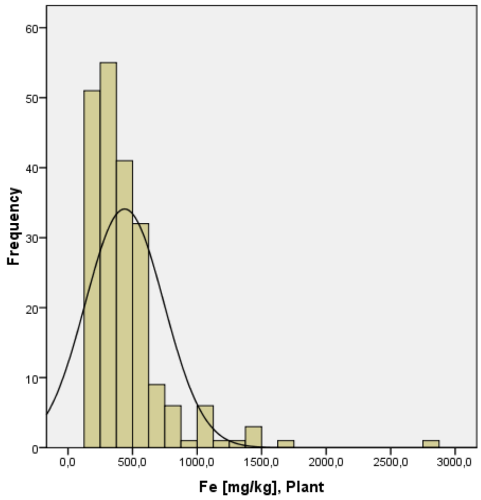


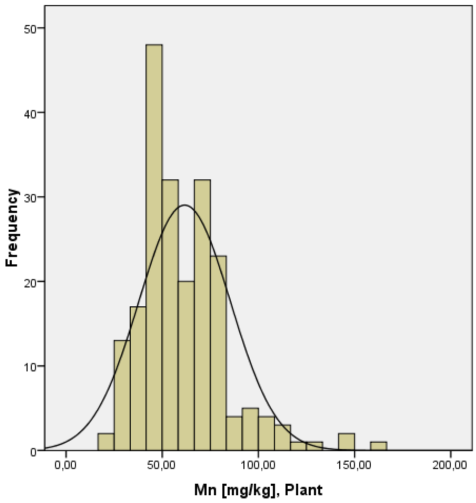
Water extractable Na (van der Paauw et al., 1971)

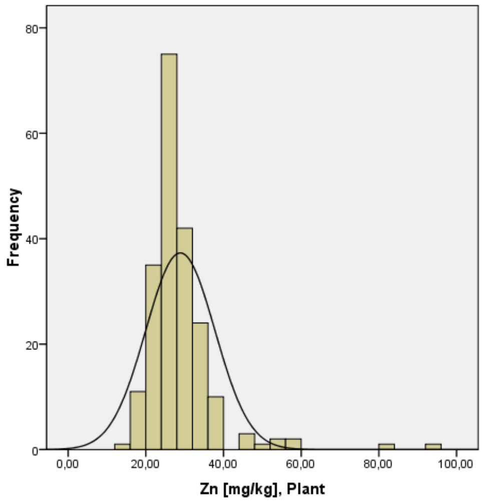
Fig. 8.2: Histogram of total element concentration in youngest, fully differentiated main stem leaf blades of organically grown Egyptian cotton (*Gossypium barbadense*).

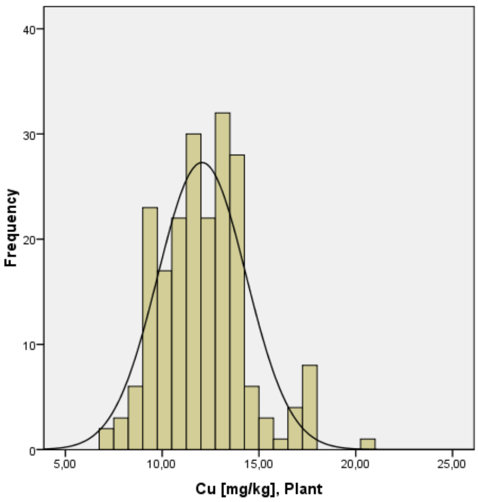


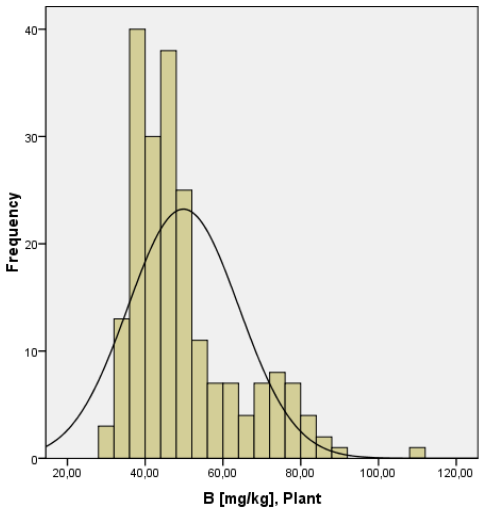

Frequency
Mg [g/kg], Plant

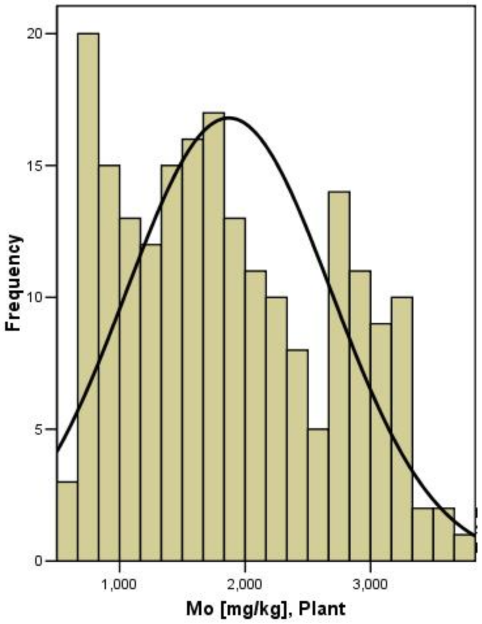

Frequency
Fe [mg/kg], Plant

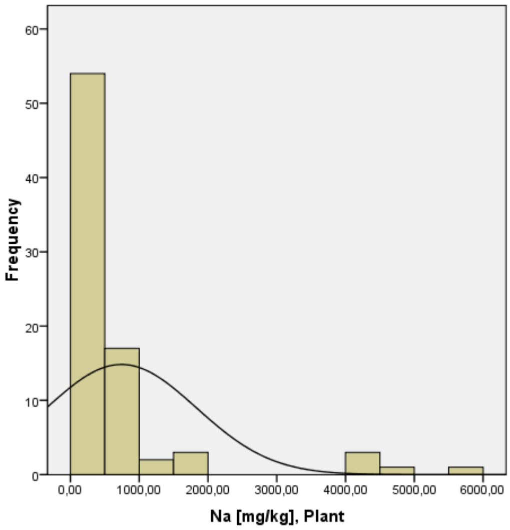

Frequency
Mn [mg/kg], Plant


Frequency
Zn [mg/kg], Plant


Frequency
Cu [mg/kg], Plant


Frequency
B [mg/kg], Plant


Frequency
Mo [mg/kg], Plant


Frequency
Na [mg/kg], Plant

Tab. 8.15: Description of the shape of distribution curves for analysis data of samples of soil and cotton (*Gossypium barbadense*) leaf tissue, sampled in 2008-2010; statistic value and standard error of Skewness and Kurtosis, statistic value and significance for the Kolmogorov-Smirnov test.

Parameters		n	Mean	Skewness		Kurtosis		Kolmogorov-Smirnov-test	
				Statistic	Std. error	Statistic	Std. error	Statistic	asymp. Sig. (2-tailed)
Soil analysis	yield [kg/ha]	208	3,470	-0.16	0.17	0.43	0.34	1.48	0.03
	rel yield [%]	208	100	-0.17	0.17	0.34	0.34	0.95	0.33
	pH-Value	208	7,9	2.56	0.17	10.29	0.34	2.52	0.00
	C_{total} [%]	206	2,16	0.91	0.17	-0.06	0.34	2.60	0.00
	C_{org} [%]	135	1,17	1.29	0.21	5.02	0.41	0.74	0.65
	$CaCO_3$ [%]	134	8,60	0.84	0.21	0.79	0.42	2.17	0.00
	N total [%]	207	0,09	1.22	0.17	4.18	0.34	0.98	0.29
	PH2O [mg/kg]	134	11,6	2.89	0.21	7.19	0.42	3.86	0.00
	PCAL [mg/kg]	207	168	2.07	0.17	4.07	0.34	2.83	0.00
	PLE [mg/kg]	125	146	1.68	0.22	1.85	0.43	2.69	0.00
	POlsen [mg/kg]	207	39,1	2.85	0.17	9.59	0.34	3.54	0.00
	SLE [mg/kg]	208	992	4.12	0.17	21.29	0.34	3.60	0.00
	KCAL [mg/kg]	208	604	3.38	0.17	11.40	0.34	4.01	0.00
	KLE [mg/kg]	208	964	3.53	0.17	12.56	0.34	4.31	0.00
	CaLE [mg/kg]	208	28,536	0.90	0.17	-0.70	0.34	3.44	0.00
	MgSchacht [mg/kg]	208	740	1.65	0.17	4.11	0.34	1.99	0.00
	Mg LE [mg/kg	208	2,635	0.11	0.17	-0.70	0.34	1.30	0.07
	Fe LE [mg/kg]	170	183	1.07	0.19	1.25	0.37	1.91	0.00
	Mn LE [mg/kg]	208	226	0.03	0.17	-1.17	0.34	1.36	0.05
	Zn West [mg/kg]	81	8,03	0.15	0.27	-0.49	0.53	0.84	0.48
	Zn LE [mg/kg]	189	4,02	8.57	0.18	89.84	0.35	4.04	0.00
	Cu West [mg/kg]	81	9,40	-0.04	0.27	-0.65	0.53	1.55	0.02
	Cu LE [mg/kg]	184	11,4	-0.32	0.18	0.04	0.36	1.26	0.08
	B LE [mg/kg]	81	5,36	1.14	0.27	0.07	0.53	2.15	0.00
	Mo LE [mg/kg]	120	0,03	4.46	0.22	21.98	0.44	3.34	0.00
	Na [mg/kg]	81	1,344	0.67	0.27	-0.57	0.53	1.40	0.04
	el. conductivity [µS/cm, 25°C]	81	1,337	1.18	0.27	0.22	0.53	1.55	0.02
	Al LE [mg/kg]	180	144	-0.94	0.18	0.09	0.36	2.12	0.00
Plant analysis	C total [%]	207	41,5	0.33	0.17	-0.19	0.34	0.74	0.64
	N total [%]	207	4,13	-0.19	0.17	-0.09	0.34	0.65	0.80
	P [g/kg]	205	3,32	0.21	0.17	0.16	0.34	0.74	0.65
	S [g/kg]	207	8,78	0.44	0.17	0.40	0.34	0.74	0.64
	K [g/kg]	207	30,3	0.16	0.17	-0.21	0.34	0.84	0.48
	Ca [g/kg]	207	26,8	0.46	0.17	0.57	0.34	1.18	0.12
	Mg [g/kg]	207	5,84	0.83	0.17	0.90	0.34	1.20	0.11
	Fe [mg/kg]	207	446	3.41	0.17	19.03	0.34	2.41	0.00
	Mn [mg/kg]	207	60,7	1.40	0.17	3.26	0.34	1.59	0.01
	Zn [mg/kg]	207	28,8	3.80	0.17	21.90	0.34	2.40	0.00
	Cu [mg/kg]	207	12,13	0.59	0.17	0.87	0.34	0.98	0.29
	B [mg/kg]	207	49,6	1.34	0.17	1.58	0.34	2.47	0.00
	Mo [mg/kg]	207	1,87	0.32	0.17	-1.01	0.34	1.09	0.19
	Na [mg/kg]	81	742	3.35	0.27	10.73	0.53	3.28	0.00

Tab. 8.16: Variation according to the year of sampling: descriptive statistics of analysis data of soil and leaf tissue samples of organically grown cotton (*Gossypium barbadense*) in Egypt in 2008-2010.

Parameter	Year	N	Mean	Standard deviation	Minimum	Maximum
rel yield [%]	2008	74	101.3	13.9	73.5	131.2
	2009	68	100.0	15.9	54.7	133.8
	2010	66	98.5	10.0	64.9	108.9
	Total	208	100.0	13.5	54.7	133.8
pH-value, soil	2008	74	7.9	0.3	7.4	8.9
	2009	68	7.9	0.2	7.6	8.5
	2010	66	7.9	0.1	7.7	8.2
	Total	208	7.9	0.2	7.4	8.9
C_{total} [%], soil	2008	73	2.2	1.0	0.8	4.6
	2009	68	2.1	1.1	0.7	4.5
	2010	65	2.2	1.1	0.7	5.4
	Total	206	2.2	1.0	0.7	5.4
C_{org} [%], soil	2008	35	1.3	0.8	0.4	4.3
	2009	40	1.3	0.5	0.5	2.6
	2010	60	1.0	0.4	0.2	2.0
	Total	135	1.2	0.6	0.2	4.3
$CaCO_3$ [%], soil	2008	34	5.8	6.0	-11.9	17.5
	2009	40	10.2	8.6	-7.2	25.7
	2010	60	9.1	6.8	3.6	30.2
	Total	134	8.6	7.3	-11.9	30.2
N_{total} [%], soil	2008	74	0.1	0.1	0.0	0.4
	2009	68	0.1	0.1	0.0	0.2
	2010	65	0.1	0.0	0.0	0.2
	Total	207	0.1	0.1	0.0	0.4
P_{H2O} [mg/kg], soil	2008	-	-	-	-	-
	2009	68	15.1	23.9	1.2	77.6
	2010	66	7.9	4.7	2.1	34.0
	Total	134	11.6	17.7	1.2	77.6
P_{CAL} [mg/kg], soil	2008	74	161.2	100.2	38.6	664.1
	2009	68	217.0	153.2	65.2	586.6
	2010	65	125.7	48.5	35.6	290.4
	Total	207	168.4	115.3	35.6	664.1
P_{LE} [mg/kg], soil	2008	0	-	-	-	-
	2009	68	177.9	174.0	6.2	530.4
	2010	57	109.0	61.2	3.8	286.6
	Total	125	146.5	138.7	3.8	530.4
POlsen [mg/kg], soil	2008	74	37.8	41.2	5.0	294.5
	2009	68	51.6	55.8	5.2	193.4
	2010	65	27.5	17.1	6.1	88.3
	Total	207	39.1	42.4	5.0	294.5
S_{LE} [mg/kg], soil	2008	74	1,030	1,979	121	10,241
	2009	68	1,352	1,036	122	4,759
	2010	66	579	560	42	2,349
	Total	208	992	1,387	42	10,241
KCAL [mg/kg], soil	2008	74	476	255	144	1,292
	2009	68	955	1,181	183	4,307
	2010	66	387	145	159	733
	Total	208	604	737	144	4,307
K_{LE} [mg/kg], soil	2008	74	840	404	360	2,279
	2009	68	1,419	1,605	448	5,912
	2010	66	634	186	300	1,065

Parameter	Year	N	Mean	Standard deviation	Minimum	Maximum
	Total	208	964	1,005	300	5,912
Ca_{LE} [mg/kg], soil	2008	74	29,805	15,719	9,018	61,967
	2009	68	28,215	15,515	10,487	59,884
	2010	66	27,442	17,484	8,492	58,284
	Total	208	28,536	16,187	8,492	61,967
MgSchacht [mg/kg], soil	2008	74	733	234	354	1,998
	2009	68	774	435	223	1,890
	2010	66	711	141	446	1,203
	Total	208	739	296	223	1,998
Mg_{LE} [mg/kg], soil	2008	74	2,696	626	1,126	3,913
	2009	68	2,702	916	1,085	4,336
	2010	66	2,496	732	1,261	4,013
	Total	208	2,635	766	1,085	4,336
Fe_{LE} [mg/kg], soil	2008	63	196	86	55	440
	2009	55	193	66	77	369
	2010	52	153	55	1	325
	Total	170	182	74	1	440
Mn_{LE} [mg/kg], soil	2008	74	225	90	41	456
	2009	68	238	122	54	422
	2010	66	215	108	32	435
	Total	208	226	107	32	456
ZnWest [mg/kg], soil	2008	0	-	-	-	-
	2009	15	5.0	6.9	0.0	21.8
	2010	66	8.7	4.8	0.0	21.8
	Total	81	8.0	5.4	0.0	21.8
Zn_{LE} [mg/kg], soil	2008	74	5.3	9.7	0.3	80.6
	2009	59	4.2	4.8	0.4	35.1
	2010	56	2.1	0.8	0.7	3.7
	Total	189	4.0	6.8	0.3	80.6
CuWest [mg/kg], soil	2008	0	-	-	-	-
	2009	15	4.4	6.4	0.3	15.9
	2010	66	10.5	5.9	0.3	26.1
	Total	81	9.4	6.4	0.3	26.1
Cu_{LE} [mg/kg], soil	2008	74	9.8	5.7	0.2	27.4
	2009	55	12.8	4.7	2.1	21.3
	2010	55	12.0	4.5	1.2	22.7
	Total	184	11.3	5.2	0.2	27.4
B_{LE} [mg/kg], soil	2008	0	-	-	-	-
	2009	15	11.45	3.28	4.63	14.87
	2010	66	3.98	2.38	1.64	10.71
	Total	81	5.36	3.87	1.64	14.87
Mo_{LE} [mg/kg], soil	2008	39	0.042	0.080	0.003	0.330
	2009	15	0.042	0.007	0.032	0.061
	2010	66	0.016	0.017	0.003	0.085
	Total	120	0.028	0.049	0.003	0.330
Na [mg/kg], soil	2008	0	-	-	-	-
	2009	15	2,376	961	528	3,561
	2010	66	1,110	866	175	3,703

Parameter	Year	N	Mean	Standard deviation	Minimum	Maximum
	Total	81	1,344	1,008	175	3,703
el. conductivity [µS/cm, 25°C]	2008	0	-	-	-	-
	2009	15	3,385	1,210	539	4,500
	2010	66	872	690	140	2,939
	Total	81	1,337	1,268	140	4,500
Al_{LE}[mg/kg]	2008	66	143.6	54.2	8.0	216.0
	2009	59	140.1	59.4	2.5	210.4
	2010	55	148.8	48.9	16.1	230.8
	Total	180	144.0	54.2	2.5	230.8
C [%], plant	2008	73	41.0	0.9	38.2	43.0
	2009	68	42.2	1.5	38.6	44.6
	2010	66	41.3	1.3	39.0	44.8
	Total	207	41.5	1.4	38.2	44.8
N [%], plant	2008	73	4.1	0.5	3.1	5.1
	2009	68	3.9	0.4	3.2	4.8
	2010	66	4.4	0.6	2.7	5.4
	Total	207	4.1	0.5	2.7	5.4
P [g/kg], plant	2008	73	3.4	0.9	1.4	5.3
	2009	68	3.2	0.8	1.7	5.3
	2010	64	3.3	0.6	2.2	5.5
	Total	205	3.3	0.8	1.4	5.5
S [g/kg], plant	2008	73	8.7	1.8	5.2	14.8
	2009	68	8.9	1.7	5.9	13.0
	2010	66	8.8	1.3	5.8	11.2
	Total	207	8.8	1.6	5.2	14.8
K [g/kg], plant	2008	73	30.6	6.7	14.1	54.9
	2009	68	29.7	7.0	19.2	45.3
	2010	66	30.4	8.0	14.1	45.5
	Total	207	30.3	7.2	14.1	54.9
Ca [g/kg], plant	2008	73	25.8	5.7	12.8	43.4
	2009	68	26.8	6.8	16.3	44.6
	2010	66	27.8	5.6	16.5	45.9
	Total	207	26.8	6.1	12.8	45.9
Mg [g/kg], plant	2008	73	5.6	0.9	4.0	7.9
	2009	68	5.5	0.6	4.0	7.3
	2010	66	6.4	1.2	3.9	9.5
	Total	207	5.8	1.0	3.9	9.5
Fe [mg/kg], plant	2008	73	395	209	130	1,182
	2009	68	545	440	166	2,846
	2010	66	401	200	169	1,064
	Total	207	446	309	130	2,846
Mn[mg/kg], plant	2008	73	58.7	26.7	20.1	143.1
	2009	68	58.3	17.0	37.4	114.8
	2010	66	65.5	22.0	24.7	165.3
	Total	207	60.7	22.5	20.1	165.3
Zn [mg/kg], plant	2008	73	30.3	7.7	15.9	54.8
	2009	68	26.7	5.9	17.4	59.7
	2010	66	29.4	12.1	17.6	95.7
	Total	207	28.8	9.0	15.9	95.7
Cu [mg/kg], plant	2008	73	10.5	1.8	7.0	17.7
	2009	68	13.3	2.2	9.3	17.8
	2010	66	12.8	1.7	9.0	20.9
	Total	207	12.1	2.3	7.0	20.9

Parameter	Year	N	Mean	Standard deviation	Minimum	Maximum
B [mg/kg], plant	2008	73	49.2	14.3	28.5	83.5
	2009	68	49.1	16.2	32.9	109.8
	2010	66	50.5	11.1	30.8	87.7
	Total	207	49.6	14.0	28.5	109.8
Mo [mg/kg], plant	2008	73	1.57	0.60	0.62	3.08
	2009	68	1.86	0.88	0.67	3.64
	2010	66	2.21	0.84	0.62	3.80
	Total	207	1.87	0.82	0.62	3.80
Na[mg/kg], plant	2008	0	-	-	-	-
	2009	15	522	163	284	777
	2010	66	793	1,201	170	5,774
	Total	81	742	1,089	170	5,774
	Total	207	351	313	74	2,786

„-„=no analysis

Tab. 8.17: Variation according to the sampling regions: descriptive statistics of analysis data of soil and leaf tissue samples of organically grown cotton (*Gossypium barbadense*) in Egypt in 2008-2010.

Parameter	Region	n	Mean	Standard deviation	Minimum	Maximum
Yield [kg/ha]	Beheira-W	41	3,724.1	479.8	1,840.9	4,500.0
	Beheira-O	55	3,708.7	450.8	2,250.0	4,687.5
	Sharqia-W	27	3,118.9	375.9	2,250.0	3,750.0
	Sharqia-O	35	3,413.5	357.9	2,362.5	3,750.0
	Dakahlia-Da.	9	3,123.7	188.7	2,812.5	3,375.0
	Qalyubia	14	3,427.1	461.0	2,625.0	4,500.0
	Faiyum	27	3,164.2	373.4	2,336.4	4,145.0
	Total	208	3,470.5	480.2	1,840.9	4,687.5
Rel. yield [%]	Beheira-W	41	107.3	13.8	54.7	133.8
	Beheira-O	55	107.0	11.4	66.9	131.2
	Sharqia-W	27	90.1	10.9	64.9	111.5
	Sharqia-O	35	98.5	10.5	70.3	111.5
	Dakahlia-Da.	9	89.7	4.3	83.6	97.3
	Qalyubia	14	98.7	13.6	78.1	133.8
	Faiyum	27	90.4	10.2	69.5	116.0
	Total	208	100.0	13.5	54.7	133.8
pH-value, soil	Beheira-W	41	7.9	0.2	7.6	8.5
	Beheira-O	55	7.9	0.3	7.4	8.9
	Sharqia-W	27	7.9	0.2	7.7	8.8
	Sharqia-O	35	7.9	0.1	7.7	8.1
	Dakahlia-Da.	9	7.9	0.1	7.8	8.1
	Qalyubia	14	7.9	0.1	7.6	8.1
	Faiyum	27	8.0	0.1	7.7	8.2
	Total	208	7.9	0.2	7.4	8.9
C_{total} [%], soil	Beheira-W	41	3.17	1.01	0.71	5.35
	Beheira-O	55	2.69	1.03	0.72	4.55
	Sharqia-W	27	1.58	0.18	1.08	1.82
	Sharqia-O	33	1.08	0.19	0.72	1.63
	Dakahlia-Da.	9	1.70	0.14	1.53	2.02
	Qalyubia	14	1.59	0.21	1.30	1.93
	Faiyum	27	1.91	0.68	1.26	3.83
	Total	206	2.16	1.05	0.71	5.35

Parameter	Region	n	Mean	Standard deviation	Minimum	Maximum
C_{org} [%], soil	Beheira-W	20	1.40	0.41	0.70	1.99
	Beheira-O	45	1.49	0.59	0.37	4.31
	Sharqia-W	21	1.07	0.57	0.22	2.61
	Sharqia-O	20	0.72	0.51	0.21	2.31
	Dakahlia-Da.	6	1.15	0.22	0.92	1.51
	Qalyubia	6	0.93	0.32	0.58	1.46
	Faiyum	17	0.81	0.40	0.40	1.79
	Total	135	1.17	0.58	0.21	4.31
$CaCO_3$ [%], soil	Beheira-W	20	16.96	7.20	2.92	30.21
	Beheira-O	45	10.21	7.55	1.24	25.67
	Sharqia-W	21	4.35	4.10	-7.16	9.61
	Sharqia-O	19	2.88	4.70	-11.90	9.44
	Dakahlia-Da.	6	4.78	1.23	3.02	6.19
	Qalyubia	6	5.56	1.05	3.95	6.55
	Faiyum	17	8.57	3.87	3.21	17.03
	Total	134	8.60	7.33	-11.90	30.21
N_{total} [%], soil	Beheira-W	41	0.11	0.04	0.00	0.19
	Beheira-O	55	0.12	0.06	0.00	0.41
	Sharqia-W	27	0.09	0.05	0.01	0.24
	Sharqia-O	34	0.06	0.04	0.01	0.23
	Dakahlia-Da.	9	0.09	0.02	0.05	0.13
	Qalyubia	14	0.07	0.02	0.03	0.11
	Faiyum	27	0.08	0.06	0.02	0.25
	Total	207	0.09	0.06	0.00	0.41
P_{H2O} [mg/kg], soil	Beheira-W	27	25.9	28.4	3.4	77.6
	Beheira-O	39	11.1	17.2	2.5	76.1
	Sharqia-W	18	5.5	3.5	2.5	14.9
	Sharqia-O	22	7.2	7.2	1.8	34.0
	Dakahlia-Da.	6	4.1	3.0	2.1	9.9
	Qalyubia	9	8.9	6.2	1.2	16.8
	Faiyum	13	4.6	2.5	1.7	9.6
	Total	134	11.6	17.7	1.2	77.6
P_{CAL} [mg/kg], soil	Beheira-W	41	216.9	167.3	66.0	586.6
	Beheira-O	55	194.4	116.9	65.2	502.8
	Sharqia-W	27	162.8	38.6	88.7	245.0
	Sharqia-O	34	124.0	52.8	73.0	260.0
	Dakahlia-Da.	9	59.7	19.6	35.6	88.2
	Qalyubia	14	160.7	69.3	72.1	302.3
	Faiyum	27	143.3	117.5	56.7	664.1
	Total	207	168.4	115.3	35.6	664.1
P_{LE} [mg/kg], soil	Beheira-W	19	272.9	233.6	3.8	530.4
	Beheira-O	39	131.1	148.0	6.2	511.3
	Sharqia-W	18	145.8	31.7	70.9	197.7
	Sharqia-O	22	107.4	52.0	57.1	275.5
	Dakahlia-Da.	6	52.3	16.8	29.5	69.2
	Qalyubia	9	179.6	73.7	77.5	286.6
	Faiyum	12	91.2	23.1	60.1	133.8
	Total	125	146.5	138.7	3.8	530.4
P_{Olsen} [mg/kg], soil	Beheira-W	41	59.4	56.2	12.0	193.4
	Beheira-O	55	49.5	42.1	10.0	190.2
	Sharqia-W	27	27.1	7.9	10.7	39.4
	Sharqia-O	34	20.6	15.5	7.0	76.8
	Dakahlia-Da.	9	19.3	6.7	11.3	29.9
	Qalyubia	14	25.7	21.5	5.0	88.3
	Faiyum	27	36.1	58.1	5.2	294.5
	Total	207	39.1	42.4	5.0	294.5
S_{LE} [mg/kg], soil	Beheira-W	41	926	799	122	4,759
	Beheira-O	55	1,559	2,159	97	10,241
	Sharqia-W	27	1,323	1,588	201	8,482

Parameter	Region	n	Mean	Standard deviation	Minimum	Maximum
	Sharqia-O	35	579	481	42	2,456
	Dakahlia-Da.	9	386	223	152	764
	Qalyubia	14	400	299	121	1,286
	Faiyum	27	652	543	145	2,257
	Total	208	992	1,387	42	10,241
K_{CAL} [mg/kg], soil	Beheira-W	41	1,110	1,192	269	4,307
	Beheira-O	55	803	760	214	3,926
	Sharqia-W	27	278	138	188	922
	Sharqia-O	35	295	68	159	532
	Dakahlia-Da.	9	275	63	183	371
	Qalyubia	14	320	126	144	573
	Faiyum	27	417	246	184	1,206
	Total	208	604	737	144	4,307
K_{LE} [mg/kg], soil	Beheira-W	41	1,650	1,667	475	5,892
	Beheira-O	55	1,201	1,017	300	5,912
	Sharqia-W	27	539	98	416	927
	Sharqia-O	35	552	83	362	809
	Dakahlia-Da.	9	522	60	460	637
	Qalyubia	14	604	177	346	970
	Faiyum	27	731	347	370	2,000
	Total	208	964	1,005	300	5,912
Ca_{LE} [mg/kg], soil	Beheira-W	41	43,770	14,956	17,441	59,221
	Beheira-O	55	34,298	17,353	16,277	59,884
	Sharqia-W	27	20,874	3,147	12,741	29,821
	Sharqia-O	35	12,793	2,483	8,492	17,710
	Dakahlia-Da.	9	14,864	5,490	10,111	25,004
	Qalyubia	14	20,923	3,953	13,627	25,612
	Faiyum	27	30,237	12,323	19,628	61,967
	Total	208	28,536	16,187	8,492	61,967
$Mg_{Schacht}$ [mg/kg], soil	Beheira-W	41	577	204	223	1,040
	Beheira-O	55	655	185	224	1,287
	Sharqia-W	27	1,097	437	440	1,890
	Sharqia-O	35	891	250	662	1,998
	Dakahlia-Da.	9	814	143	584	966
	Qalyubia	14	607	187	414	991
	Faiyum	27	648	157	354	1,103
	Total	208	739	296	223	1,998
Mg_{LE} [mg/kg], soil	Beheira-W	41	2,759	884	1,085	4,013
	Beheira-O	55	2,522	829	1,106	3,813
	Sharqia-W	27	3,380	616	2,260	4,336
	Sharqia-O	35	2,656	386	1,995	3,913
	Dakahlia-Da.	9	2,530	208	2,233	2,831
	Qalyubia	14	1,960	504	1,261	2,844
	Faiyum	27	2,288	571	1,126	3,169
	Total	208	2,635	766	1,085	4,336
Fe_{LE} [mg/kg], soil	Beheira-W	20	149	83	1	423
	Beheira-O	40	177	95	78	440
	Sharqia-W	27	250	59	150	369
	Sharqia-O	35	174	32	99	244
	Dakahlia-Da.	9	267	44	192	325
	Qalyubia	14	162	28	93	190
	Faiyum	25	136	26	94	207
	Total	170	182	74	1	440
Mn_{LE} [mg/kg], soil	Beheira-W	41	234	110	92	422
	Beheira-O	55	250	98	81	400
	Sharqia-W	27	239	68	84	352
	Sharqia-O	35	115	73	32	392
	Dakahlia-Da.	9	168	113	79	378
	Qalyubia	14	316	65	213	435

Parameter	Region	n	Mean	Standard deviation	Minimum	Maximum
	Faiyum	27	266	97	49	456
	Total	208	226	107	32	456
Zn_{West} [mg/kg], soil	Beheira-W	14	2.59	2.84	0.00	8.75
	Beheira-O	34	8.70	6.44	0.00	21.76
	Sharqia-W	8	10.91	4.46	8.53	21.85
	Sharqia-O	9	8.11	1.49	6.20	10.56
	Dakahlia-Da.	4	13.10	3.46	8.71	16.61
	Qalyubia	5	10.86	1.82	8.40	13.55
	Faiyum	7	7.36	0.55	6.32	7.99
	Total	81	8.03	5.39	0.00	21.85
Zn_{LE} [mg/kg], soil	Beheira-W	32	4.10	3.14	0.43	9.82
	Beheira-O	46	6.15	12.01	0.44	80.61
	Sharqia-W	27	2.85	0.85	1.56	5.09
	Sharqia-O	35	2.04	0.88	0.67	3.71
	Dakahlia-Da.	9	2.69	0.83	1.41	3.99
	Qalyubia	14	2.81	0.95	1.44	4.65
	Faiyum	26	5.14	7.30	0.34	35.14
	Total	189	4.02	6.78	0.34	80.61
Cu_{West} [mg/kg], soil	Beheira-W	14	2.40	2.54	0.33	7.31
	Beheira-O	34	8.57	6.65	0.33	16.07
	Sharqia-W	8	13.92	1.09	12.31	15.74
	Sharqia-O	9	11.78	1.41	9.81	13.52
	Dakahlia-Da.	4	21.32	5.95	13.69	26.13
	Qalyubia	5	13.80	1.39	11.72	15.49
	Faiyum	7	9.28	2.83	4.37	12.67
	Total	81	9.40	6.44	0.33	26.13
Cu_{LE} [mg/kg], soil	Beheira-W	31	8.17	7.30	0.19	21.26
	Beheira-O	42	12.19	5.74	0.27	27.38
	Sharqia-W	27	14.47	3.58	2.63	21.30
	Sharqia-O	35	11.56	2.23	7.06	16.47
	Dakahlia-Da.	9	15.68	4.36	10.43	22.66
	Qalyubia	14	12.91	2.45	10.55	19.49
	Faiyum	26	7.89	2.83	0.26	12.43
	Total	184	11.35	5.23	0.19	27.38
B_{LE} [mg/kg], soil	Beheira-W	14	8.03	1.57	5.86	10.71
	Beheira-O	34	6.55	4.99	1.97	14.87
	Sharqia-W	8	3.51	0.47	2.77	4.16
	Sharqia-O	9	2.76	0.74	1.76	4.07
	Dakahlia-Da.	4	3.52	0.39	3.13	4.06
	Qalyubia	5	2.25	0.43	1.64	2.84
	Faiyum	7	2.98	0.52	2.25	3.59
	Total	81	5.36	3.87	1.64	14.87
Mo_{LE} [mg/kg], soil	Beheira-W	23	0.029	0.016	0.007	0.069
	Beheira-O	50	0.042	0.070	0.005	0.330
	Sharqia-W	9	0.022	0.044	0.004	0.140
	Sharqia-O	11	0.006	0.004	0.003	0.013
	Dakahlia-Da.	4	0.004	0.000	0.004	0.004
	Qalyubia	5	0.009	0.002	0.007	0.011
	Faiyum	18	0.014	0.006	0.003	0.022
	Total	120	0.028	0.049	0.003	0.330
Na [mg/kg], soil	Beheira-W	14	1,618	620	763	2,617
	Beheira-O	34	1,365	1,238	202	3,561
	Sharqia-W	8	2,283	789	1,176	3,703
	Sharqia-O	9	815	618	175	1,860
	Dakahlia-Da.	4	1,321	380	765	1,622
	Qalyubia	5	454	183	251	753
	Faiyum	7	953	583	477	2,124
	Total	81	1,344	1,008	175	3,703
el. conductivity	Beheira-W	14	1,374	542	482	2,197

Parameter	Region	n	Mean	Standard deviation	Minimum	Maximum
[µS/cm, 25°C]	Beheira-O	34	1,773	1,727	200	4,500
	Sharqia-W	8	1,580	664	704	2,861
	Sharqia-O	9	520	421	140	1,388
	Dakahlia-Da.	4	917	296	498	1,182
	Qalyubia	5	566	394	281	1,234
	Faiyum	7	709	526	288	1,460
	Total	81	1,337	1,268	140	4,500
Al_{LE}[mg/kg]	Beheira-W	26	82	59	8	210
	Beheira-O	44	120	53	2	216
	Sharqia-W	27	173	22	94	215
	Sharqia-O	35	185	19	146	226
	Dakahlia-Da.	9	189	24	153	231
	Qalyubia	14	164	25	104	213
	Faiyum	25	135	43	61	194
	Total	180	144	54	2	231
C [%], plant	Beheira-W	41	41.1	1.1	38.2	42.7
	Beheira-O	55	40.7	0.9	38.6	42.7
	Sharqia-W	27	42.1	1.6	39.0	44.6
	Sharqia-O	35	42.6	1.3	39.6	44.8
	Dakahlia-Da.	8	42.1	0.6	41.5	43.0
	Qalyubia	14	42.2	1.1	40.4	44.1
	Faiyum	27	41.1	1.3	38.4	44.6
	Total	207	41.5	1.4	38.2	44.8
N [%], plant	Beheira-W	41	4.32	0.45	3.44	5.25
	Beheira-O	55	4.17	0.44	3.05	5.09
	Sharqia-W	27	4.31	0.67	3.25	5.43
	Sharqia-O	35	3.97	0.47	3.15	4.99
	Dakahlia-Da.	8	3.60	0.78	2.68	4.51
	Qalyubia	14	4.02	0.33	3.34	4.45
	Faiyum	27	4.00	0.35	3.12	4.51
	Total	207	4.13	0.51	2.68	5.43
P [g/kg], plant	Beheira-W	41	3.42	0.61	2.10	4.98
	Beheira-O	55	3.38	0.72	2.18	5.27
	Sharqia-W	27	3.70	0.71	2.70	5.29
	Sharqia-O	35	3.49	0.70	1.72	5.47
	Dakahlia-Da.	8	4.07	0.44	3.45	4.95
	Qalyubia	14	2.95	0.77	1.76	4.51
	Faiyum	25	2.32	0.52	1.42	3.41
	Total	205	3.32	0.78	1.42	5.47
S [g/kg], plant	Beheira-W	41	9.58	1.07	7.36	12.77
	Beheira-O	55	9.13	1.14	6.87	12.54
	Sharqia-W	27	7.60	1.52	5.88	11.09
	Sharqia-O	35	7.41	1.13	5.23	11.63
	Dakahlia-Da.	8	8.35	1.55	5.70	10.24
	Qalyubia	14	7.96	1.12	5.77	9.82
	Faiyum	27	10.34	1.74	7.38	14.81
	Total	207	8.78	1.62	5.23	14.81
K [g/kg], plant	Beheira-W	41	33.3	3.8	23.0	39.8
	Beheira-O	55	36.2	6.2	25.3	54.9
	Sharqia-W	27	25.2	4.1	19.2	35.6
	Sharqia-O	35	24.7	5.1	14.1	38.6
	Dakahlia-Da.	8	23.9	5.5	17.3	31.5
	Qalyubia	14	22.1	4.8	14.1	28.6
	Faiyum	27	31.9	5.4	16.6	39.5
	Total	207	30.3	7.2	14.1	54.9
Ca [g/kg], plant	Beheira-W	41	29.5	4.3	23.5	43.4
	Beheira-O	55	28.1	7.0	12.8	44.6
	Sharqia-W	27	25.4	7.0	16.3	40.9
	Sharqia-O	35	23.4	5.6	16.5	45.9

Parameter	Region	n	Mean	Standard deviation	Minimum	Maximum
	Dakahlia-Da.	8	23.5	3.3	18.9	28.1
	Qalyubia	14	26.1	3.5	18.7	29.8
	Faiyum	27	27.2	5.4	16.5	40.9
	Total	207	26.8	6.1	12.8	45.9
Mg [g/kg], plant	Beheira-W	41	5.96	1.04	4.56	8.98
	Beheira-O	55	6.07	0.95	4.47	7.70
	Sharqia-W	27	6.26	1.33	4.68	9.50
	Sharqia-O	35	5.59	0.68	3.87	7.18
	Dakahlia-Da.	8	4.99	0.31	4.49	5.44
	Qalyubia	14	5.68	1.02	3.96	7.85
	Faiyum	27	5.42	0.79	4.30	7.97
	Total	207	5.84	1.00	3.87	9.50
Fe [mg/kg], plant	Beheira-W	41	284.0	83.8	169.3	524.0
	Beheira-O	55	343.5	213.8	130.0	1,182.1
	Sharqia-W	27	509.5	398.2	213.0	1,674.7
	Sharqia-O	35	582.0	484.7	169.3	2,845.8
	Dakahlia-Da.	8	629.5	332.9	170.7	1,049.2
	Qalyubia	14	473.9	119.6	325.6	717.5
	Faiyum	27	592.2	152.7	395.4	1,062.3
	Total	207	446.0	309.2	130.0	2,845.8
Mn[mg/kg], plant	Beheira-W	41	59.6	17.0	32.9	104.1
	Beheira-O	55	55.3	15.9	24.7	83.9
	Sharqia-W	27	47.2	11.7	30.4	82.3
	Sharqia-O	35	62.2	13.9	44.1	94.4
	Dakahlia-Da.	8	40.8	22.4	20.1	81.7
	Qalyubia	14	58.6	17.2	29.9	98.0
	Faiyum	27	92.3	31.2	46.5	165.3
	Total	207	60.7	22.5	20.1	165.3
Zn [mg/kg], plant	Beheira-W	41	29.5	6.3	19.4	54.8
	Beheira-O	55	28.8	6.0	17.4	47.4
	Sharqia-W	27	30.6	12.4	19.8	83.6
	Sharqia-O	35	25.1	7.2	15.9	59.7
	Dakahlia-Da.	8	28.7	4.2	24.5	35.8
	Qalyubia	14	31.3	7.4	23.2	52.1
	Faiyum	27	29.7	14.8	20.4	95.7
	Total	207	28.8	9.0	15.9	95.7
Cu [mg/kg], plant	Beheira-W	41	13.0	2.6	7.3	17.8
	Beheira-O	55	12.8	2.0	7.6	17.7
	Sharqia-W	27	11.7	1.8	8.8	14.3
	Sharqia-O	35	11.1	2.1	7.0	17.2
	Dakahlia-Da.	8	11.6	2.0	9.4	14.9
	Qalyubia	14	13.1	1.6	11.4	17.4
	Faiyum	27	10.9	2.5	8.0	20.9
	Total	207	12.1	2.3	7.0	20.9
B [mg/kg], plant	Beheira-W	41	44.5	8.2	34.0	79.5
	Beheira-O	55	47.1	13.2	28.5	109.8
	Sharqia-W	27	47.2	11.3	32.9	72.5
	Sharqia-O	35	43.1	8.6	30.8	78.2
	Dakahlia-Da.	8	44.8	10.5	36.1	61.9
	Qalyubia	14	51.7	7.2	37.2	60.3
	Faiyum	27	73.7	8.9	55.6	91.3
	Total	207	49.6	14.0	28.5	109.8
Mo [mg/kg], plant	Beheira-W	41	2.21	0.59	1.09	3.80
	Beheira-O	55	2.46	0.85	0.62	3.64
	Sharqia-W	27	1.42	0.59	0.67	2.73
	Sharqia-O	35	1.19	0.42	0.68	2.13
	Dakahlia-Da.	8	1.07	0.26	0.85	1.56
	Qalyubia	14	1.27	0.40	0.62	2.19
	Faiyum	27	2.04	0.65	0.96	3.08

Parameter	Region	n	Mean	Standard deviation	Minimum	Maximum
	Total	207	1.87	0.82	0.62	3.80
Na[mg/kg], plant	Beheira-W	14	389.1	93.6	276.5	556.7
	Beheira-O	34	420.0	141.3	284.3	776.6
	Sharqia-W	8	686.4	396.1	195.9	1,275.8
	Sharqia-O	9	857.9	1,357.3	228.0	4,447.1
	Dakahlia-Da.	4	404.1	64.5	342.6	474.0
	Qalyubia	5	198.2	25.4	170.4	236.0
	Faiyum	7	3,512.5	1,695.4	1,536.0	5,774.2
	Total	81	742.4	1,089.5	170.4	5,774.2

Tab. 8.18: Variation according to the certification as organic or according to “demeter”: descriptive statistics of data of soil and leaf tissue samples of organically grown cotton (*Gossypium barbadense*) at Beheira governorate in Egypt in 2008-2010.

Parameter	Certification	n	Mean	Standard deviation	Minimum	Maximum
Yield [kg/ha]	demeter	38	3,736	419	2,605	4,500
	organic	58	3,702	489	1,841	4,688
	Total	96	3,715	461	1,841	4,688
Rel. yield [%]	demeter	38	107.6	12.2	77.5	133.8
	organic	58	106.9	12.6	54.7	131.2
	Total	96	107.2	12.4	54.7	133.8
pH-value, soil	demeter	38	7.9	0.2	7.6	8.4
	organic	58	7.9	0.3	7.4	8.9
	Total	96	7.9	0.2	7.4	8.9
C_{total} [%], soil	demeter	38	3.2	1.0	0.7	5.4
	organic	58	2.7	1.0	0.7	4.6
	Total	96	2.9	1.0	0.7	5.4
C_{org} [%], soil	demeter	22	1.4	0.4	0.7	2.0
	organic	43	1.5	0.6	0.4	4.3
	Total	65	1.5	0.5	0.4	4.3
$CaCO_3$ [%], soil	demeter	22	16.3	7.2	2.9	30.2
	organic	43	10.2	7.7	1.2	25.7
	Total	65	12.3	8.0	1.2	30.2
N_{total} [%], soil	demeter	38	0.1	0.0	0.0	0.2
	organic	58	0.1	0.1	0.0	0.4
	Total	96	0.1	0.1	0.0	0.4
P_{H2O} [mg/kg], soil	demeter	26	26.5	29.2	3.4	77.6
	organic	40	11.1	16.5	2.5	70.4
	Total	66	17.2	23.4	2.5	77.6
P_{CAL} [mg/kg], soil	demeter	38	219	160	70	587
	organic	58	194	126	65	536
	Total	96	204	140	65	587
P_{LE} [mg/kg], soil	demeter	18	248	228	4	530
	organic	40	146	165	6	511
	Total	58	178	191	4	530
P_{Olsen} [mg/kg], soil	demeter	38	66	57	13	193
	organic	58	46	40	10	190
	Total	96	54	49	10	193
S_{LE} [mg/kg], soil	demeter	38	1,025	828	213	4,759
	organic	58	1,462	2,123	97	10,241
	Total	96	1,289	1,737	97	10,241
K_{CAL} [mg/kg], soil	demeter	38	1,160	1,214	214	4,307
	organic	58	786	754	245	3,926
	Total	96	934	974	214	4,307
K_{LE} [mg/kg], soil	demeter	38	1,748	1,776	300	5,912
	organic	58	1,160	909	457	4,973

Parameter	Certification	n	Mean	Standard deviation	Minimum	Maximum
	Total	96	1,392	1,344	300	5,912
Ca_{LE} [mg/kg], soil	demeter	38	44,883	14,164	17,441	59,221
	organic	58	34,058	17,372	16,277	59,884
	Total	96	38,343	16,957	16,277	59,884
MgSchacht [mg/kg], soil	demeter	38	594	199	252	1,040
	organic	58	640	194	223	1,287
	Total	96	622	196	223	1,287
Mg_{LE} [mg/kg], soil	demeter	38	2,768	860	1,085	4,013
	organic	58	2,528	848	1,106	3,813
	Total	96	2,623	856	1,085	4,013
Fe_{LE} [mg/kg], soil	demeter	18	151	85	1	423
	organic	42	174	94	55	440
	Total	60	167	91	1	440
Mn_{LE} [mg/kg], soil	demeter	38	224	108	81	404
	organic	58	256	98	91	422
	Total	96	243	103	81	422
ZnWest [mg/kg], soil	demeter	16	2.76	2.68	0.00	8.75
	organic	32	9.00	6.52	0.00	21.76
	Total	48	6.92	6.26	0.00	21.76
Zn_{LE} [mg/kg], soil	demeter	29	4.09	3.24	0.43	9.73
	organic	49	6.03	11.65	0.44	80.61
	Total	78	5.31	9.45	0.43	80.61
CuWest [mg/kg], soil	demeter	16	2.66	2.48	0.33	7.31
	organic	32	8.83	6.78	0.33	16.07
	Total	48	6.77	6.39	0.33	16.07
Cu_{LE} [mg/kg], soil	demeter	28	8.09	7.30	0.19	21.26
	organic	45	11.97	5.92	0.27	27.38
	Total	73	10.48	6.71	0.19	27.38
B_{LE} [mg/kg], soil	demeter	16	7.80	1.59	5.86	10.71
	organic	32	6.57	5.15	1.97	14.87
	Total	48	6.98	4.32	1.97	14.87
Mo_{LE} [mg/kg], soil	demeter	24	0.03	0.02	0.01	0.09
	organic	49	0.04	0.07	0.01	0.33
	Total	73	0.04	0.06	0.01	0.33
Na [mg/kg], soil	demeter	16	1,726	715	763	3,308
	organic	32	1,296	1,226	202	3,561
	Total	48	1,439	1,094	202	3,561
el. conductivity [µS/cm, 25°C]	demeter	16	1,486	639	482	2,939
	organic	32	1,742	1,769	200	4,500
	Total	48	1,657	1,486	200	4,500
Salt [mgKCl/100 g soil]	demeter	16	476	204	154	940
	organic	32	557	566	64	1,440
	Total	48	530	476	64	1,440
Al_{LE}[mg/kg]	demeter	23	75	47	8	199
	organic	47	120	58	2	216
	Total	70	106	58	2	216
C [%], plant	demeter	38	41.0	1.1	38.2	42.7
	organic	58	40.8	0.9	38.6	42.7
	Total	96	40.9	1.0	38.2	42.7
N [%], plant	demeter	38	4.39	0.45	3.44	5.25
	organic	58	4.13	0.42	3.05	4.91
	Total	96	4.23	0.45	3.05	5.25
P [g/kg], plant	demeter	38	3.36	0.60	2.10	4.98
	organic	58	3.42	0.72	2.18	5.27
	Total	96	3.39	0.67	2.10	5.27
S [g/kg], plant	demeter	38	9.52	1.15	7.36	12.77
	organic	58	9.18	1.10	6.87	12.54
	Total	96	9.32	1.12	6.87	12.77
K [g/kg], plant	demeter	38	33.0	4.4	23.0	43.8

Parameter	Certification	n	Mean	Standard deviation	Minimum	Maximum
	organic	58	36.3	5.8	26.3	54.9
	Total	96	35.0	5.5	23.0	54.9
Ca [g/kg], plant	demeter	38	29.8	4.3	23.9	43.4
	organic	58	28.0	6.8	12.8	44.6
	Total	96	28.7	6.0	12.8	44.6
Mg [g/kg], plant	demeter	38	5.99	1.08	4.56	8.98
	organic	58	6.04	0.93	4.47	7.70
	Total	96	6.02	0.99	4.47	8.98
Fe [mg/kg], plant	demeter	38	288	87	169	524
	organic	58	338	209	130	1,182
	Total	96	318	173	130	1,182
Mn[mg/kg], plant	demeter	38	57.1	18.0	24.7	104.1
	organic	58	57.2	15.4	26.9	95.0
	Total	96	57.1	16.4	24.7	104.1
Zn [mg/kg], plant	demeter	38	29.7	7.0	19.4	54.8
	organic	58	28.7	5.4	17.4	47.4
	Total	96	29.1	6.1	17.4	54.8
Cu [mg/kg], plant	demeter	38	12.8	2.6	7.3	17.8
	organic	58	12.9	2.1	7.6	17.7
	Total	96	12.9	2.3	7.3	17.8
B [mg/kg], plant	demeter	38	45.3	8.4	35.5	79.5
	organic	58	46.4	13.0	28.5	109.8
	Total	96	46.0	11.4	28.5	109.8
Mo [mg/kg], plant	demeter	38	2.26	0.54	1.22	3.80
	organic	58	2.41	0.87	0.62	3.64
	Total	96	2.35	0.76	0.62	3.80
Na[mg/kg], plant	demeter	16	382	90	276	557
	organic	32	426	144	284	777
	Total	48	411	129	276	777

Fig. 8.3: Boxplot of element concentrations in soils and tissue samples of young, fully matured leaf blades of *Gossypium barbandese* at seven different regions in Egypt, sampled 2008-2010.

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<tr><th></th><th>Soil samples</th><th>Tissue samples</th></tr>
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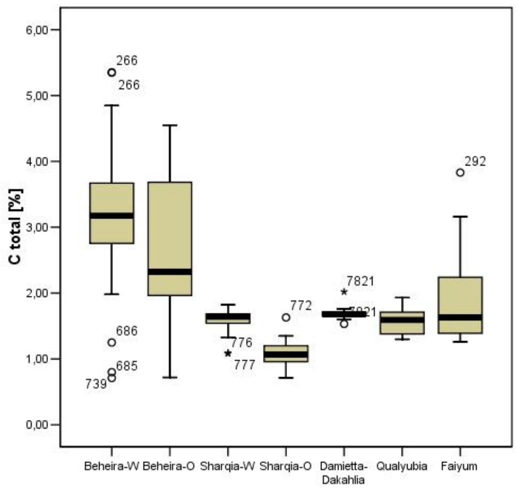

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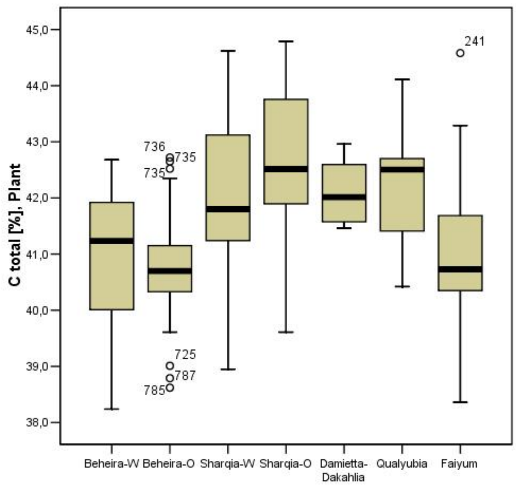

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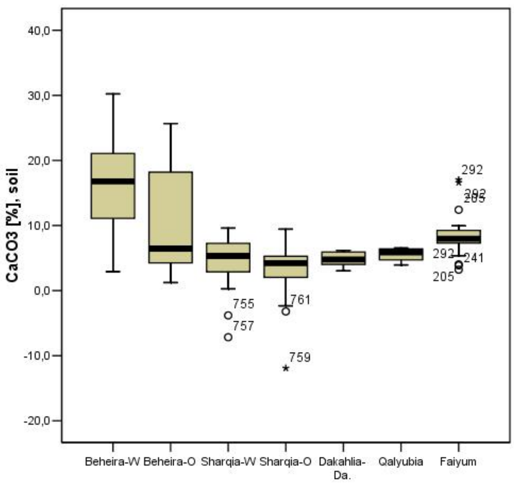

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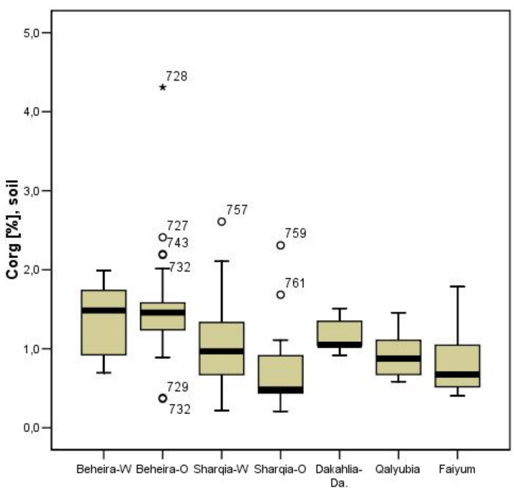

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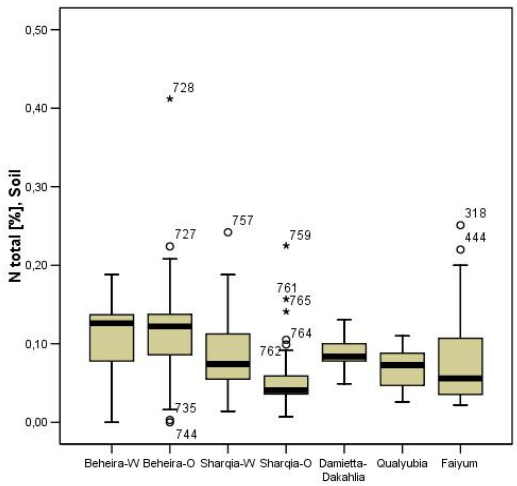
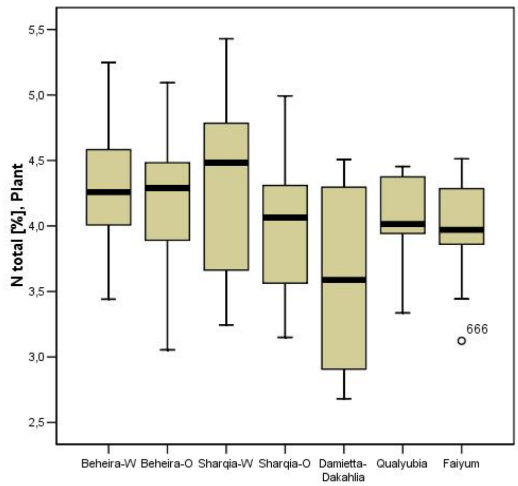
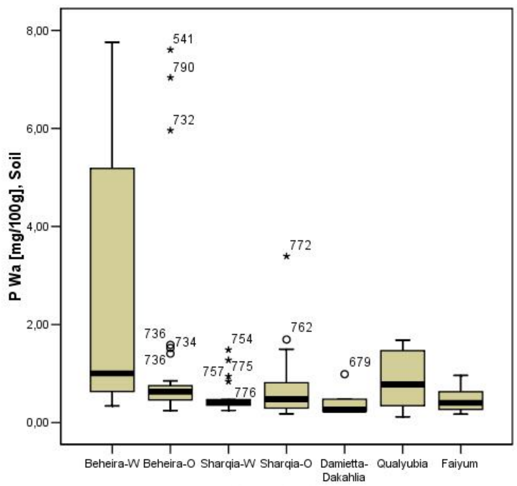
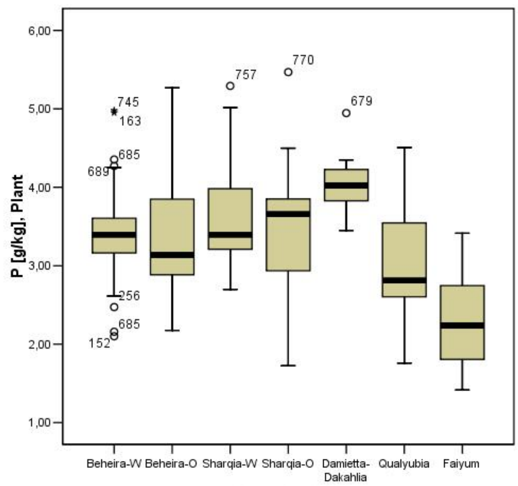
Nitrogen

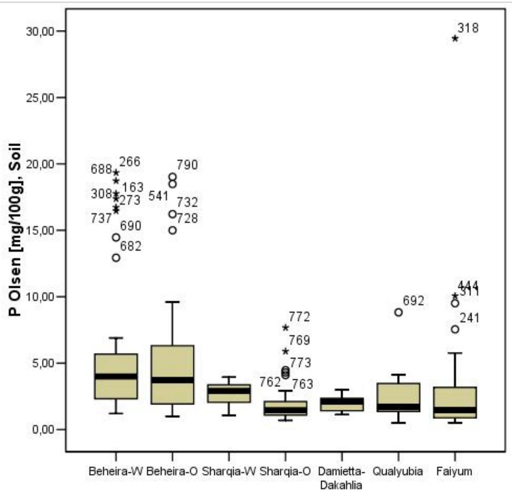


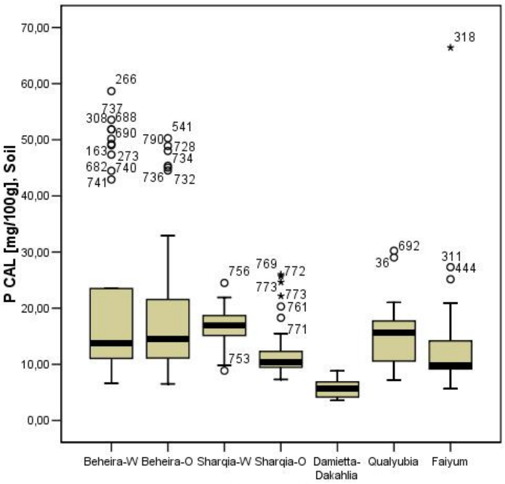


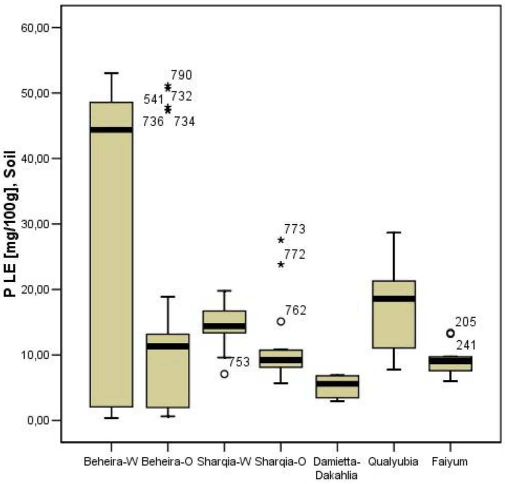




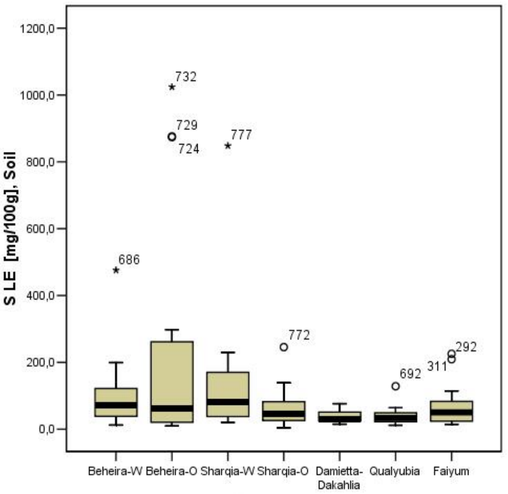
Phosphorus

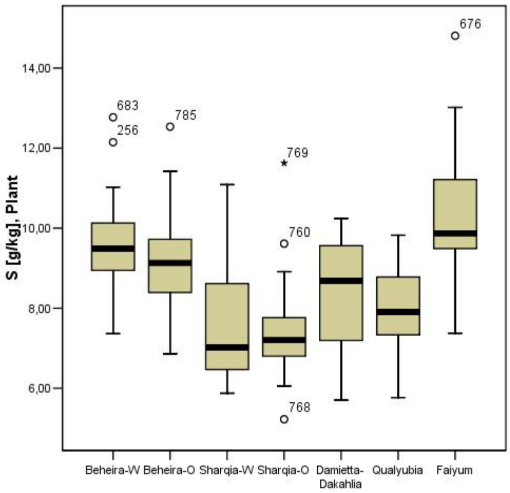



P CAL [mg/100g], Soil
70,00
60,00
50,00
40,00
30,00
20,00
10,00
0,00
Beheira-W
Beheira-O
Sharqia-W
Sharqia-O
Damietta-Dakahlia
Qualyubia
Faiyum


P LE [mg/100g], Soil
60,00
50,00
40,00
30,00
20,00
10,00
0,00
Beheira-W
Beheira-O
Sharqia-W
Sharqia-O
Damietta-Dakahlia
Qualyubia
Faiyum

Sulphur


S LE [mg/100g], Soil
1200,0
1000,0
800,0
600,0
400,0
200,0
0,0
Beheira-W
Beheira-O
Sharqia-W
Sharqia-O
Damietta-Dakahlia
Qualyubia
Faiyum


S [g/kg], Plant
14,00
12,00
10,00
8,00
6,00
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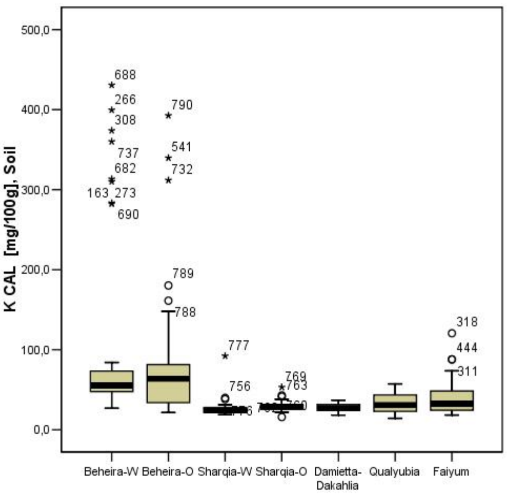
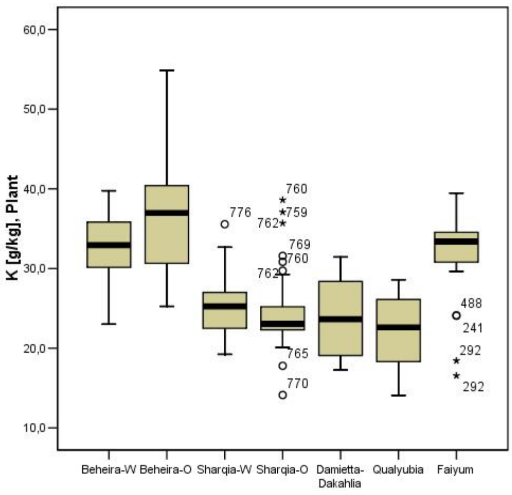
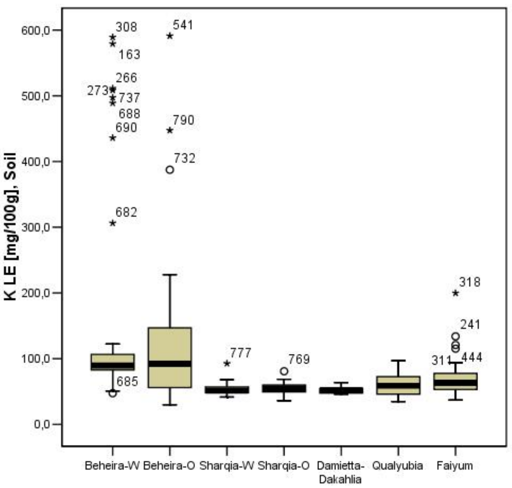
Beheira-O
Sharqia-W
Sharqia-O
Damietta-Dakahlia
Qualyubia
Faiyum

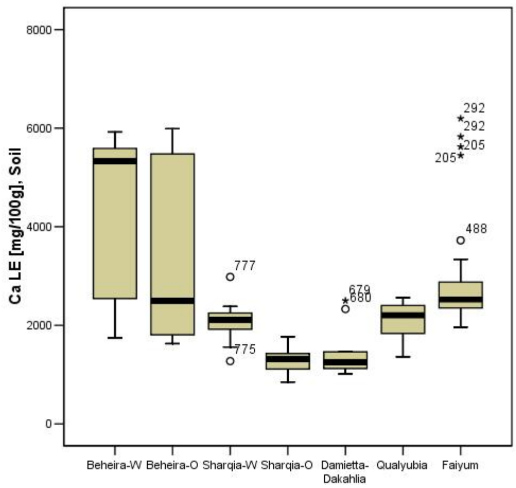
Potassium

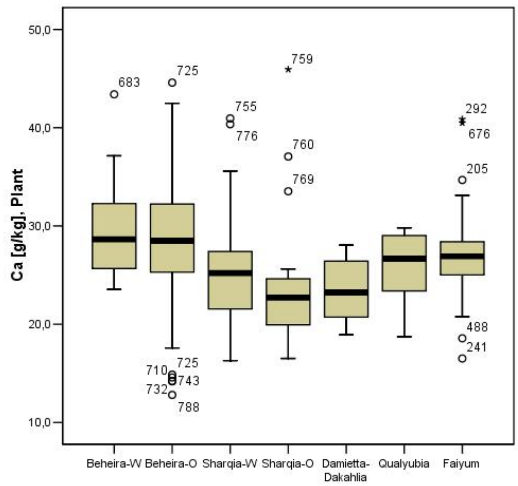

K CAL [mg/100g], Soil
Beheira-W
Beheira-O
Sharqia-W
Sharqia-O
Damietta-Dakahlia
Qualyubia
Faiyum

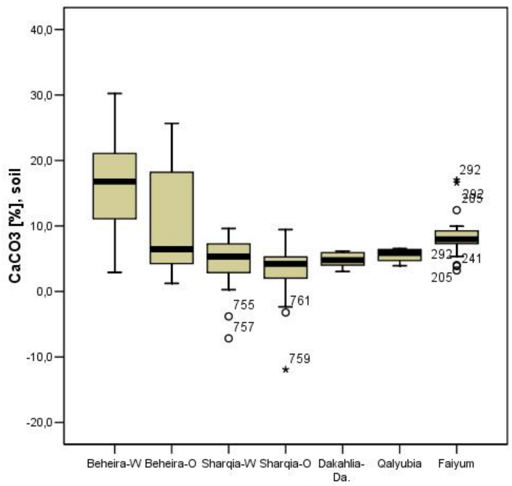

K [g/kg], Plant
Beheira-W
Beheira-O
Sharqia-W
Sharqia-O
Damietta-Dakahlia
Qualyubia
Faiyum


K LE [mg/100g], Soil
Beheira-W
Beheira-O
Sharqia-W
Sharqia-O
Damietta-Dakahlia
Qualyubia
Faiyum

Calcium







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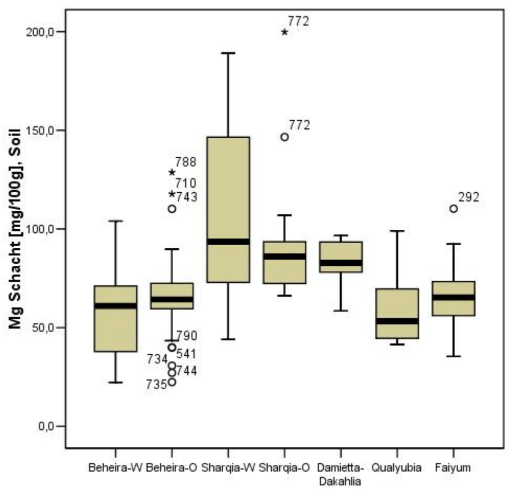

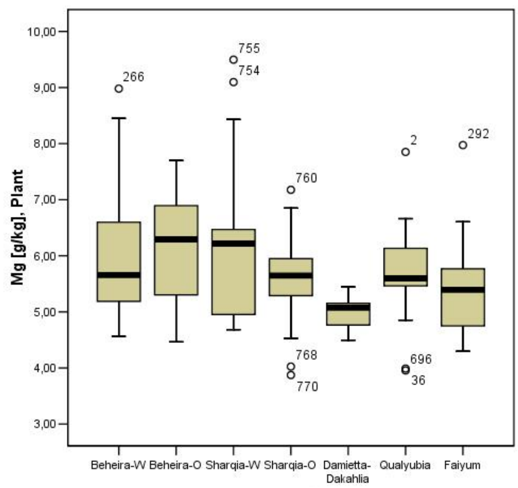

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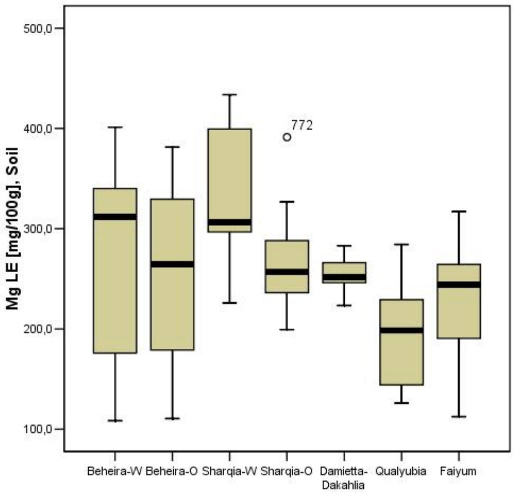

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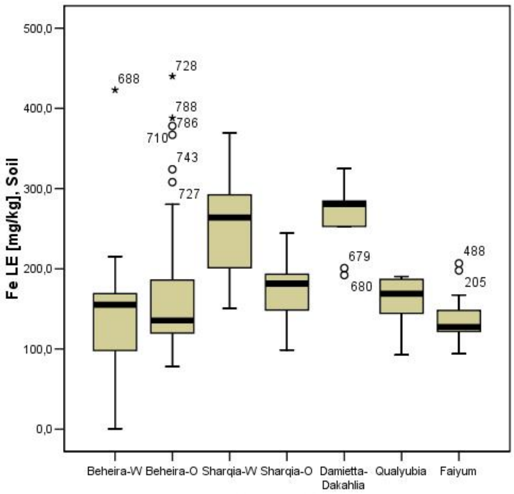
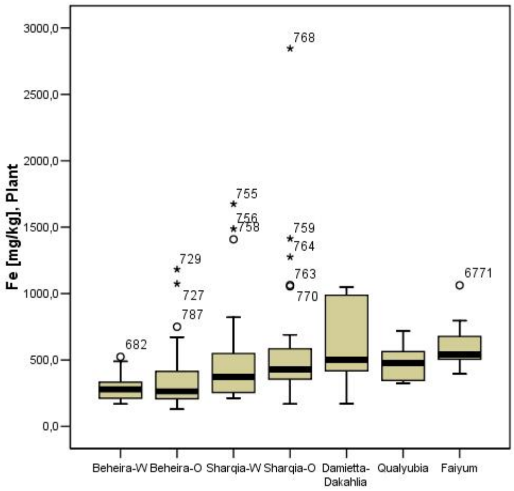
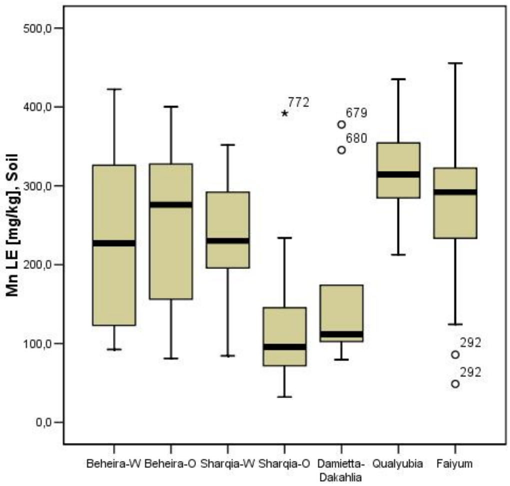
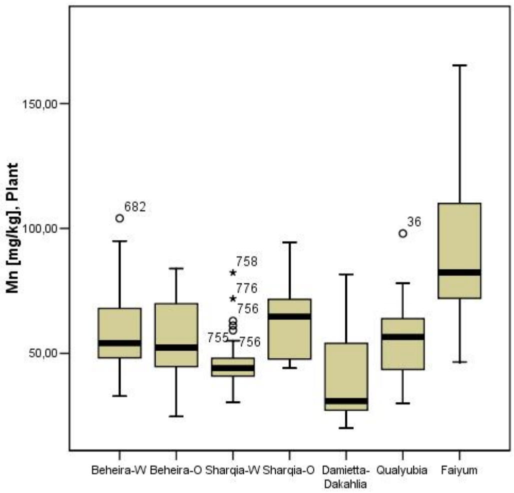


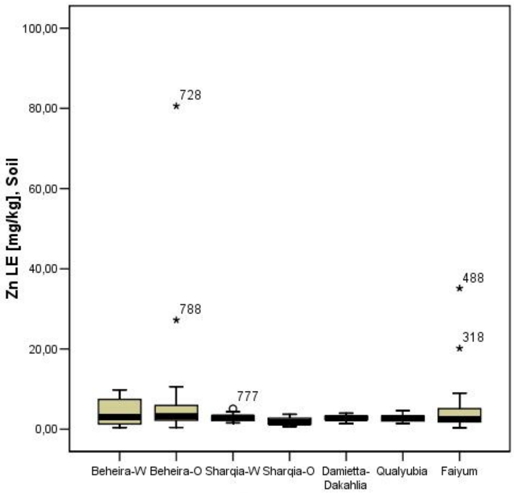


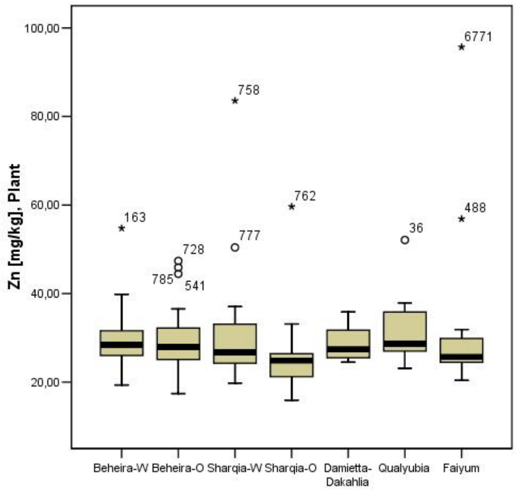
Manganese





Zinc


Zn LE [mg/kg], Soil
0,00
20,00
40,00
60,00
80,00
100,00
728
788
777
488
318
Beheira-W Beheira-O Sharqia-W Sharqia-O Damietta-Dakahlia Qualyubia Faiyum


Zn [mg/kg], Plant
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60,00
80,00
100,00
6771
758
163
728
785
541
777
762
36
488
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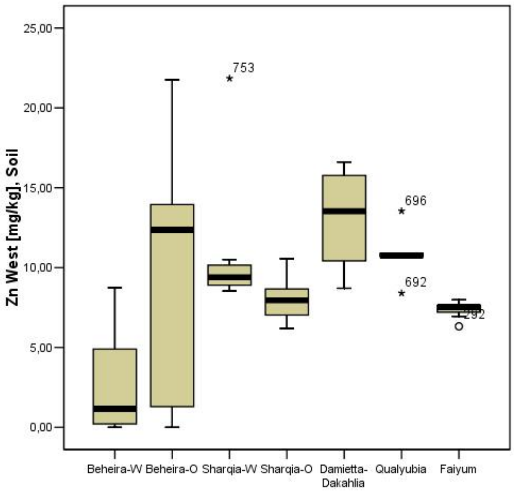
Zn West [mg/kg], Soil
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5,00
10,00
15,00
20,00
25,00
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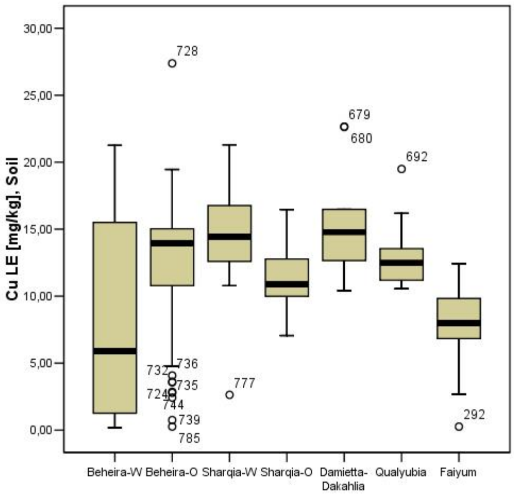
696
692
292
Beheira-W Beheira-O Sharqia-W Sharqia-O Damietta-Dakahlia Qualyubia Faiyum

Copper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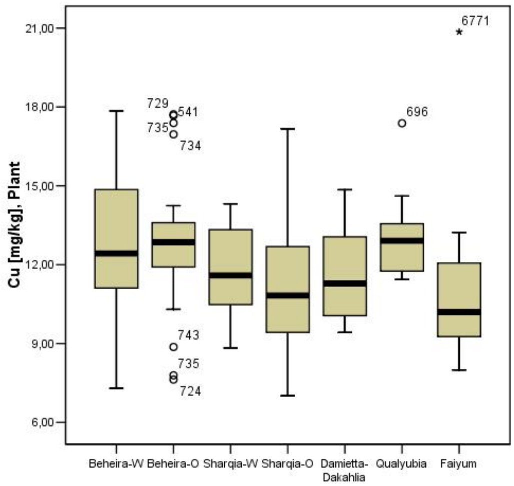
5,00
10,00
15,00
20,00
25,00
30,00
728
679
680
692
736
732
735
724
744
739
785
777
292
Beheira-W Beheira-O Sharqia-W Sharqia-O Damietta-Dakahlia Qualyubia Faiyum


Cu [mg/kg], Plant
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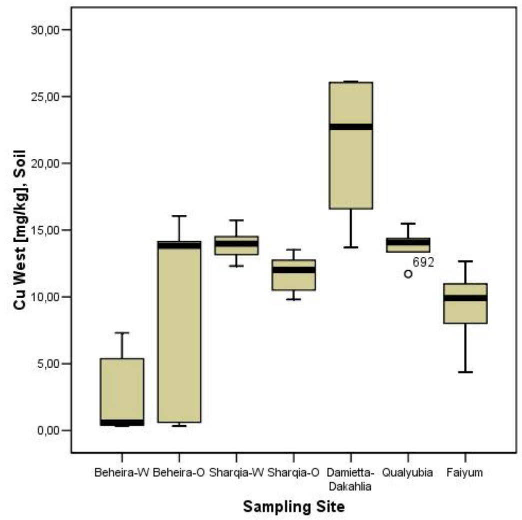
9,00
12,00
15,00
18,00
21,00
6771
729
541
735
734
696
743
735
724
Beheira-W Beheira-O Sharqia-W Sharqia-O Damietta-Dakahlia Qualyubia Faiyum

Copper



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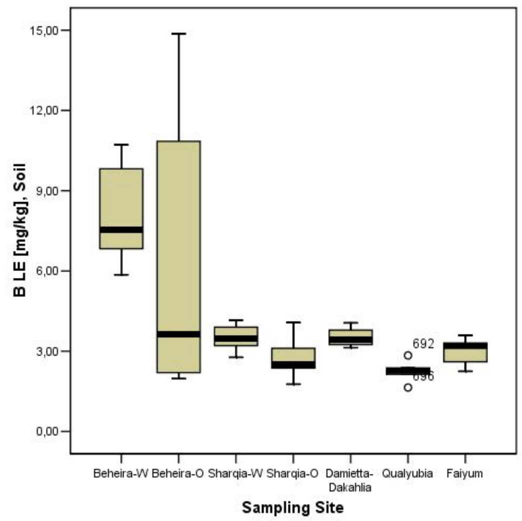

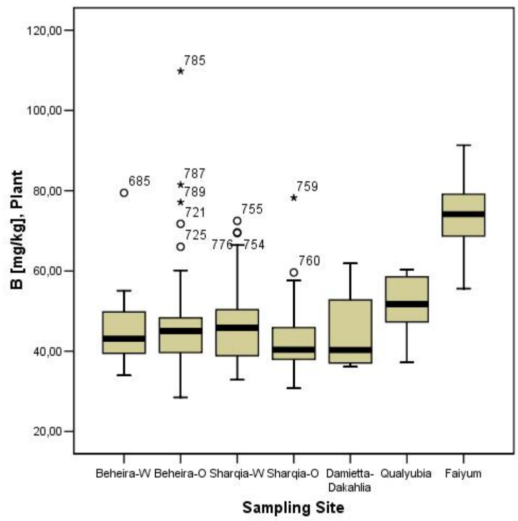

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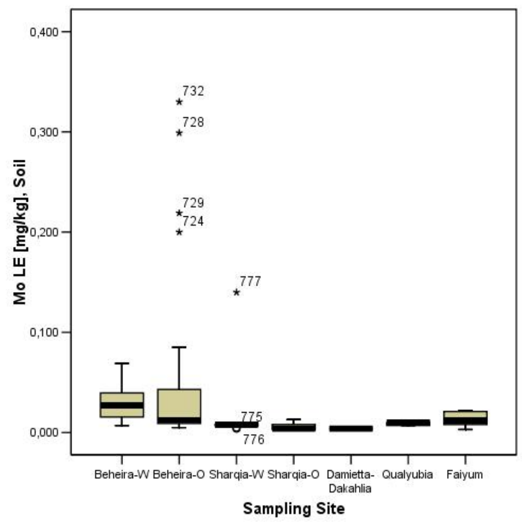
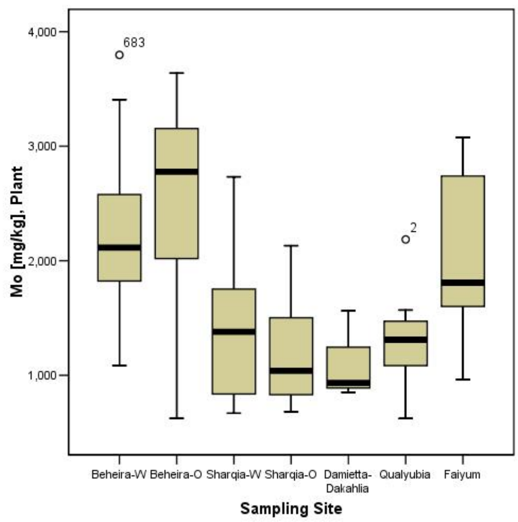
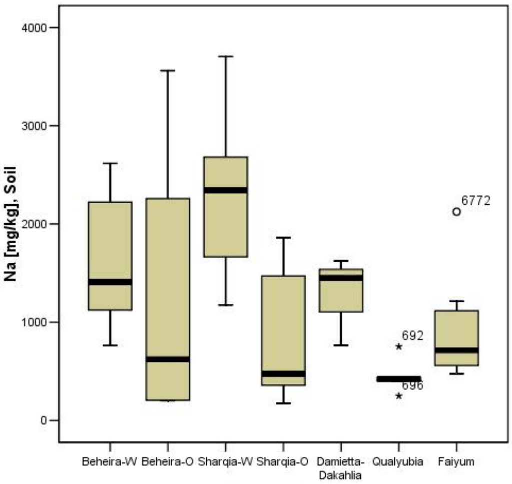
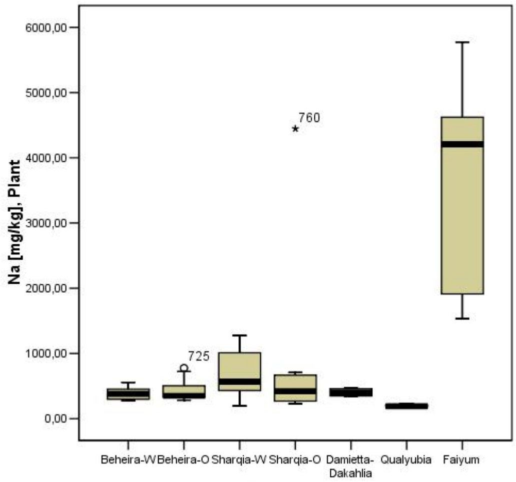
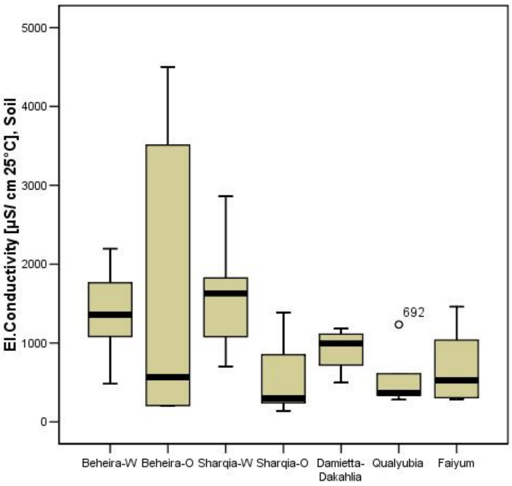




Sodium







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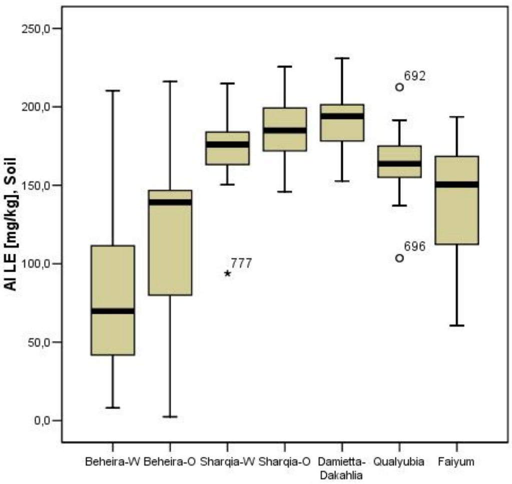


Tab. 8.19: Significant differences between means according to the year of sampling, sampling region and certification according to "organic" and "demeter" standards (certificate): results of ANOVA of analysis data of soil and leaf tissue samples of organically grown cotton (*Gossypium barbadense*) in Egypt in 2008-2010.

	Parameters	Year	Region	Certificate
	Yield [kg/ha]	x	x	-
	Rel. yield [%]	-	x	-
Soil parameters	pH-value	-	-	-
	C_{total} [%]	-	x	x
	C_{org} [%]	x	x	-
	$CaCO_3$ [%]	x	x	x
	N_{total} [%]	-	x	-
	P_{H2O} [mg/kg]	x	x	x
	P_{CAL} [mg/kg]	x	x	-
	P_{LE} [mg/kg]	x	x	-
	P_{Olsen} [mg/kg]	x	x	x
	S_{LE} [mg/kg]	x	x	-
	K_{CAL} [mg/kg]	x	x	-
	K_{LE} [mg/kg]	x	x	x
	Ca_{LE} [mg/kg]	-	x	x
	$Mg_{Schacht}$ [mg/kg]	-	x	-
	Mg_{LE} [mg/kg]	-	x	-
	Fe_{LE} [mg/kg]	x	x	-
	Mn_{LE} [mg/kg]	-	x	-
	Zn_{West} [mg/kg]	x	x	x
	Zn_{LE} [mg/kg]	x	-	-
	Cu_{West} [mg/kg]	x	x	x
	Cu_{LE} [mg/kg]	x	x	x
	B_{LE} [mg/kg]	x	x	-
	Mo_{LE} [mg/kg]	x	-	-
	Na [mg/kg]	x	x	-
	el. conductivity [µS/cm, 25°C]	x	-	-
	Al_{LE}[mg/kg]	-	x	-
Plant parameters	C [%]	x	x	-
	N [%]	x	x	x
	P [g/kg]	-	x	-
	S [g/kg]	-	x	-
	K [g/kg]	-	x	x
	Ca [g/kg]	-	x	-
	Mg [g/kg]	x	x	-
	Fe [mg/kg]	x	x	-
	Mn[mg/kg]	-	x	-
	Zn [mg/kg]	x	-	-
	Cu [mg/kg]	x	x	-
	B [mg/kg]	-	x	-
	Mo [mg/kg]	x	x	-
	Na[mg/kg]	-	x	-

"x"=difference between means ($p<0.05$)

"-"=no difference between means ($p>0.05$)

Tab. 8.20: Calculation sheet for the determination of mean tissue concentrations of plant nutrients of the best 15 % of organically grown Egyptian cotton (*Gossypium barbadense*).

% of Total	Rel. production	Farm no.	C	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo	Na
0	133.8	36	42.0	3.96	4.51	9.82	28.2	26.6	4.0	624.2	43.2	29.1	13.6	47.3	1.345	
1	133.8	266	42.3	4.22	3.58	9.20	31.9	27.1	4.8	170.2	48.2	27.6	16.3	37.4	2.272	
1	131.2	732	41.2	4.60	4.28	8.04	41.6	14.6	6.9	142.0	36.5	28.9	12.0	44.7	0.998	
2	131.2	785	40.6	4.19	4.18	12.54	32.2	26.7	5.3	598.0	49.4	45.9	11.0	60.1	3.002	
2	125.9	727	40.8	4.49	3.85	8.11	31.0	20.6	7.7	1074.0	43.0	33.2	11.5	37.0	0.724	
3	125.7	688	42.0	4.24	3.26	9.61	34.2	28.3	4.9	210.8	52.7	30.5	17.7	39.5	2.388	
3	125.5	163	41.9	4.02	3.71	10.76	31.9	27.6	4.9	234.1	43.7	29.0	15.4	36.0	2.082	
4	125.5	685	41.2	4.26	2.91	9.84	38.2	31.0	5.2	202.1	53.7	28.4	17.7	43.4	2.400	
4	124.2	739	41.7	3.80	3.60	8.67	32.7	23.2	5.3	298.0	49.6	36.5	10.6	39.2	1.501	
5	123.9	308	41.2	4.14	3.10	10.12	37.0	31.8	5.5	240.6	52.6	26.1	15.0	40.8	2.421	
5	122.7	686	42.3	4.43	3.18	9.52	30.2	26.4	6.2	187.9	80.1	29.4	14.3	41.2	1.805	
6	122.4	541	40.5	5.09	4.42	8.19	31.3	30.9	5.0	192.0	41.6	44.5	12.0	37.6	1.763	
6	121.1	685	39.9	3.82	2.10	9.39	32.0	37.1	6.9	333.0	69.4	25.6	7.3	79.5	1.685	
7	121.1	725	41.1	3.80	4.66	7.92	54.9	14.9	7.4	163.0	33.2	30.0	10.5	48.2	2.162	
7	120.7	743	41.4	4.29	4.20	7.68	41.5	14.2	6.5	130.0	33.1	24.6	8.9	41.0	1.349	
8	119.9	788	41.4	3.76	4.24	6.87	42.1	12.8	6.9	162.0	38.1	25.1	12.4	41.8	1.097	
8	119.6	739	41.7	4.45	3.55	10.45	34.6	28.7	5.7	221.7	60.8	29.0	17.1	40.8	2.311	
9	119.2	728	41.2	3.93	4.79	10.40	30.3	24.7	4.6	652.0	45.4	47.4	11.7	36.5	1.384	
9	118.9	690	39.8	4.28	3.49	8.95	34.8	32.7	7.0	249.0	90.9	39.8	10.4	51.3	1.456	
10	117.9	737	42.6	4.58	3.46	9.32	29.8	25.7	6.3	217.2	62.2	29.6	15.2	41.6	2.114	
10	117.1	725	39.0	3.26	2.18	9.60	40.3	44.6	5.5	671.7	49.4	19.6	12.8	66.0	3.637	776.6
11	116.4	541	40.3	4.17	2.90	10.95	43.8	34.8	6.4	217.0	51.5	24.7	17.4	46.7	2.349	
11	116.0	677	40.0	3.97	2.81	12.86	37.4	29.8	6.1	540.4	143.1	25.3	9.1	83.5	1.619	
12	115.4	163	40.9	5.01	4.98	9.00	29.0	29.1	4.6	192.0	40.9	54.8	13.1	36.4	1.823	
12	113.7	787	38.6	3.30	2.57	10.28	43.7	42.5	6.2	750.1	58.6	22.2	13.5	81.5	3.287	722.7
13	113.7	710	40.2	4.13	3.88	7.18	47.6	14.2	6.7	180.0	30.0	22.9	12.4	45.3	2.216	
13	113.7	786	41.2	3.96	3.87	9.34	32.5	25.7	5.2	327.0	49.4	34.1	11.2	37.8	1.485	
13	113.4	729	41.0	4.75	3.85	7.71	30.0	20.9	7.6	1182.1	46.7	32.3	17.7	37.0	0.671	
14	112.6	740	40.1	4.01	3.59	7.89	34.8	31.0	6.2	317.0	95.0	25.7	9.9	45.0	1.585	
14	112.4	308	41.7	4.57	3.20	9.16	26.8	27.8	4.9	249.0	58.6	31.2	13.7	35.5	2.995	
15	112.4	736	39.6	4.07	2.84	7.99	37.7	29.5	6.6	332.0	81.4	39.8	12.5	52.1	2.061	
15	111.6	745	41.2	3.48	4.95	9.56	32.5	25.1	5.0	386.0	46.0	34.4	11.7	38.5	1.121	
Mean			**41.0**	**4.2**	**3.6**	**9.3**	**35.5**	**26.9**	**5.9**	**363.9**	**55.6**	**31.5**	**13.0**	**46.6**	**1.9**	**749.7**
Standard deviation			**1.0**	**0.4**	**0.8**	**1.4**	**6.3**	**7.6**	**1.0**	**265.3**	**22.5**	**8.0**	**2.8**	**13.3**	**0.7**	**38.1**

Tab. 8.21: Calculation sheet for the determination of critical values according to Cate and Nelson (1971) for the plant nutrient phosphorus/relative yield of organically grown Egyptian cotton (*Gossypium barbadense*).

P [g/kg]; last value included in population 1	Xi=rel. cotton production [%]	Xi^2	mean(Xi1)	mean(Xi2)	n(Xi1)	n(Xi2)	Summe $Xi1^2$	Summe $Xi2^2$	CSS1	CSS2	R^2 for postulated critical level	Farm no.
TCSS: 37.989												
1.42	96.5	9,314	96.51	100.1	1	207	9 314	2 112 139	0	37,976	0.00	457
1.54	83.9	7,047	90.23	98.45	2	206	16 362	2 105 092	79	108,529	-1.86	292
1.55	104.9	11,011	95.13	100.2	3	205	27 373	2 094 081	223	36,738	0.03	300
1.7	81.1	6,578	91.62	100.2	4	204	33 951	2 087 503	371	41,144	-0.09	292
1.72	83.9	7,047	90.09	100.2	5	203	40 998	2 080 456	418	40,329	-0.07	768
1.7	106.9	11,422	92.89	100.3	6	202	52 419	2 069 034	653	35,703	0.04	488
1.76	94.4	8,919	93.11	100.3	7	201	61 338	2 060 115	655	38,157	-0.02	2
1.8	89.2	7,959	92.62	100.3	8	200	69 298	2 052 156	668	39,088	-0.05	318
1.80	82.9	6,866	91.54	100.4	9	199	76 164	2 045 290	753	40,068	-0.07	692
1.8	76.9	5,921	90.08	100.5	10	198	82,085	2,039,369	944	40,722	-0.10	311
2.10	121.1	14,675	92.9	100.6	11	197	96,760	2,024,693	1,821	31,436	0.12	685
2.16	104.9	11,011	93.9	100.5	12	196	107,771	2,013,682	1,954	34,654	0.04	152
2.2	117.1	13,711	95.69	100.5	13	195	121,482	1,999,971	2,450	31,930	0.09	725
2.2	98.7	9,732	95.9	100.4	14	194	131,214	1,990,239	2,459	35,614	0.00	205
2.2	69.5	4,828	94.14	100.4	15	193	136,042	1,985,411	3,110	40,517	-0.15	241
2.22	97.3	9,476	94.34	100.5	16	192	145,518	1,975,935	3,120	34,941	0.00	292
2.23	94.4	8,919	94.35	100.6	17	191	154,437	1,967,016	3,120	35,491	-0.02	666
2.24	83.9	7,047	93.77	100.6	18	190	161,484	1,959,969	3,222	37,332	-0.07	318
2.24	94.4	8,919	93.8	100.7	19	189	170,403	1,951,050	3,222	35,199	-0.01	205
2.26	94.4	8,919	93.83	100.7	20	188	179,322	1,942,131	3,223	35,166	-0.01	258
2.3	100.4	10,074	94.15	100.7	21	187	189,396	1,932,057	3,263	33,979	0.02	724
2.38	108.2	11,699	94.78	100.8	22	186	201,095	1,920,358	3,451	32,354	0.06	759
2.40	86.5	7,487	94.42	100.7	23	185	208,582	1,912,871	3,516	36,502	-0.05	677
2.41	82.9	6,872	93.94	100.8	24	184	215,454	1,905,999	3,643	36,931	-0.07	676
2.44	78.7	6,194	93.33	100.9	25	183	221,648	1,899,805	3,866	37,307	-0.08	677
2.4	66.9	4,477	92.32	101	26	182	226,125	1,895,328	4,538	38,553	-0.13	788
2.47	104.9	11,011	92.79	101.2	27	181	237,136	1,884,317	4,691	30,888	0.06	256
2.49	102.8	10,558	93.14	101.2	28	180	247,695	1,873,759	4,787	31,323	0.05	760
2.5	110.4	12,189	93.74	101.2	29	179	259,884	1,861,570	5,074	29,688	0.08	729
2.54	94.1	8,853	93.75	101.1	30	178	268,737	1,852,716	5,075	32,927	0.00	205
2.6	113.7	12,939	94.39	101.2	31	177	281,676	1,839,777	5,462	28,800	0.10	787
2.59	96.0	9,209	94.44	101.1	32	176	290,885	1,830,568	5,464	32,356	0.00	241
2.6	78.1	6,094	93.95	101.1	33	175	296,979	1,824,475	5,724	35,451	-0.08	694
2.61	80.6	6,500	93.55	101.2	34	174	303,479	1,817,974	5,896	34,537	-0.06	613
2.61	101.4	10,282	93.78	101.4	35	173	313,761	1,807,692	5,956	30,351	0.04	273
2.67	97.3	9,476	93.88	101.4	36	172	323,238	1,798,216	5,969	31,157	0.02	6961
2.69	93.7	8,787	93.87	101.4	37	171	332,025	1,789,428	5,969	31,835	0.00	682
2.7	89.2	7,959	93.75	101.4	38	170	339,984	1,781,469	5,990	32,613	-0.02	759
2.70	83.9	7,047	93.5	101.5	39	169	347,031	1,774,422	6,083	33,390	-0.04	755
2.7	107.8	11,621	93.86	101.6	40	168	358,653	1,762,801	6,283	28,527	0.08	728
2.75	87.4	7,647	93.7	101.6	41	167	366,299	1,755,154	6,323	32,455	-0.02	444
2.75	108.2	11,699	94.05	101.7	42	166	377,998	1,743,455	6,527	28,219	0.09	788
2.8	89.2	7,959	93.93	101.6	43	165	385,958	1,735,496	6,550	31,908	-0.01	692
2.78	102.8	10,558	94.13	101.7	44	164	396,516	1,724,937	6,626	29,170	0.06	725
2.79	108.2	11,699	94.45	101.7	45	163	408,215	1,713,238	6,818	28,027	0.08	692
2.79	108.2	11,699	94.74	101.6	46	162	419,914	1,701,539	7,002	27,977	0.08	726
2.81	82.3	6,768	94.48	101.6	47	161	426,682	1,694,771	7,155	32,857	-0.05	677
2.81	116.0	13,453	94.93	101.7	48	160	440,135	1,681,318	7,608	25,820	0.12	677
2.83	97.1	9,421	94.97	101.6	49	159	449,557	1,671,897	7,612	29,629	0.02	778
2.8	94.8	8,985	94.97	101.7	50	158	458,542	1,662,912	7,612	30,050	0.01	740
2.84	112.4	12,640	95.31	101.7	51	157	471,182	1,650,271	7,911	26,356	0.10	736
2.9	100.4	10,074	95.41	101.6	52	156	481,256	1,640,198	7,936	28,793	0.03	734
2.9	106.2	11,280	95.61	101.6	53	155	492,536	1,628,917	8,051	27,586	0.06	768
2.86	108.2	11,699	95.84	101.6	54	154	504,235	1,617,218	8,206	27,141	0.07	732
2.86	86.5	7,487	95.67	101.6	55	153	511,722	1,609,731	8,291	31,301	-0.04	736

P [g/kg]; last value included in population 1	Xi=rel. cotton production [%]	Xi²	mean(Xi1)	mean(Xi2)	n(Xi1)	n(Xi2)	Summe Xi1²	Summe Xi2²	CSS1	CSS2	R^2 for postulated critical level	Farm no.
2.87	108.2	11,699	95.9	101.7	56	152	523,422	1,598,032	8,444	26,881	0.07	728
2.9	89.8	8,070	95.79	101.6	57	151	531,492	1,589,962	8,480	30,459	-0.03	766
2.9	100.4	10,074	95.87	101.7	58	150	541,565	1,579,888	8,501	28,331	0.03	784
2.88	102.8	10,558	95.99	101.7	59	149	552,124	1,569,330	8,547	27,847	0.04	760
2.88	86.5	7,487	95.83	101.7	60	148	559,611	1,561,842	8,635	30,915	-0.04	6771
2.9	94.8	8,985	95.81	101.8	61	147	568,597	1,552,857	8,636	29,206	0.00	770
2.90	95.1	9,041	95.8	101.9	62	146	577,637	1,543,816	8,637	29,111	0.01	724
2.9	116.4	13,541	96.13	101.9	63	145	591,179	1,530,275	9,053	24,573	0.11	541
2.9	125.5	15,740	96.58	101.8	64	144	606,919	1,514,535	9,900	22,144	0.16	685
2.9	89.2	7,959	96.47	101.6	65	143	614,878	1,506,576	9,953	29,328	-0.03	760
2.92	83.9	7,047	96.28	101.7	66	142	621,925	1,499,528	10,108	30,102	-0.06	488
2.92	103.0	10,611	96.38	101.9	67	141	632,536	1,488,917	10,153	26,245	0.04	787
2.94	86.5	7,487	96.24	101.8	68	140	640,024	1,481,430	10,248	29,366	-0.04	736
3.0	70.3	4,936	95.86	102	69	139	644,960	1,476,494	10,913	31,703	-0.12	767
3.0	89.2	7,959	95.76	102.2	70	138	652,919	1,468,534	10,957	27,715	-0.02	696
2.97	98.7	9,746	95.81	102.3	71	137	662,665	1,458,788	10,965	25,778	0.03	241
2.98	103.5	10,704	95.91	102.3	72	136	673,369	1,448,084	11,023	24,813	0.06	790
2.98	108.2	11,699	96.08	102.3	73	135	685,068	1,436,385	11,171	23,815	0.08	731
3.00	83.9	7,047	95.92	102.2	74	134	692,115	1,429,338	11,316	28,423	-0.05	774
3.0	54.7	2,997	95.37	102.4	75	133	695,112	1,426,341	12,989	32,163	-0.19	741
3.01	64.9	4,212	94.97	102.7	76	132	699,324	1,422,130	13,905	28,736	-0.12	755
3.02	86.5	7,487	94.86	103	77	131	706,811	1,414,642	13,975	24,076	0.00	753
3.0	100.4	10,074	94.93	103.2	78	130	716,885	1,404,569	14,005	21,242	0.07	769
3.04	91.6	8,394	94.89	103.2	79	129	725,279	1,396,174	14,016	22,918	0.03	727
3.0	111.5	12,436	95.09	103.3	80	128	737,716	1,383,738	14,289	18,759	0.13	789
3.05	98.4	9,688	95.13	103.2	81	127	747,404	1,374,050	14,300	21,426	0.06	6772
3.1	97.0	9,413	95.16	103.2	82	126	756,817	1,364,637	14,304	21,685	0.05	710
3.1	105.9	11,224	95.29	103.3	83	125	768,041	1,353,413	14,419	19,846	0.10	721
3.1	123.9	15,354	95.63	103.3	84	124	783,394	1,338,059	15,228	15,704	0.19	308
3.1	111.5	12,436	95.82	103.1	85	123	795,831	1,325,623	15,478	18,158	0.11	772
3.11	108.9	11,853	95.97	103	86	122	807,684	1,313,770	15,646	18,656	0.10	743
3.1	111.5	12,436	96.15	103	87	121	820,120	1,301,333	15,885	18,028	0.11	732
3.1	111.5	12,436	96.32	102.9	88	120	832,557	1,288,897	16,119	17,940	0.10	753
3.12	108.2	11,699	96.45	102.8	89	119	844,256	1,277,198	16,258	18,588	0.08	786
3.1	105.6	11,162	96.56	102.8	90	118	855,418	1,266,036	16,341	19,088	0.07	682
3.14	97.3	9,476	96.56	102.8	91	117	864,894	1,256,559	16,342	20,760	0.02	785
3.1	102.8	10,559	96.63	102.8	92	116	875,453	1,246,000	16,380	19,657	0.05	785
3.15	105.0	11,021	96.72	102.8	93	115	886,474	1,234,980	16,449	19,196	0.06	730
3.16	104.9	11,011	96.81	102.8	94	114	897,485	1,223,969	16,515	19,196	0.06	686
3.2	89.2	7,959	96.73	102.8	95	113	905,444	1,216,009	16,572	22,240	-0.02	791
3.2	122.7	15,048	97	102.9	96	112	920,492	1,200,961	17,238	14,990	0.15	686
3.19	108.2	11,699	97.11	102.7	97	111	932,191	1,189,262	17,362	17,908	0.07	729
3.19	101.4	10,282	97.16	102.7	98	110	942,474	1,178,980	17,380	19,285	0.03	689
3.2	89.2	7,959	97.08	102.7	99	109	950,433	1,171,021	17,442	21,609	-0.03	777
3.2	100.4	10,074	97.11	102.8	100	108	960,506	1,160,947	17,453	19,337	0.03	754
3.20	112.4	12,640	97.26	102.8	101	107	973,147	1,148,307	17,685	16,769	0.09	308
3.22	102.5	10,500	97.31	102.7	102	106	983,647	1,137,807	17,712	18,798	0.04	266
3.22	94.4	8,919	97.29	102.7	103	105	992,566	1,128,888	17,720	20,379	0.00	754
3.23	103.5	10,704	97.35	102.8	104	104	1,003,270	1,118,184	17,758	18,541	0.04	789
3.24	101.0	10,191	97.38	102.8	105	103	1,013,461	1,107,993	17,771	19,052	0.03	688
3.25	86.5	7,487	97.28	102.8	106	102	1,020,948	1,100,505	17,888	21,756	-0.04	775
3.3	125.7	15,812	97.54	103	107	101	1,036,761	1,084,693	18,691	13,195	0.16	688
3.26	108.2	11,699	97.64	102.8	108	100	1,048,460	1,072,994	18,802	16,740	0.06	784
3.26	108.2	11,699	97.74	102.7	109	99	1,060,159	1,061,295	18,912	16,699	0.06	692
3.26	104.9	11,011	97.8	102.7	110	98	1,071,170	1,050,284	18,963	17,346	0.04	759
3.3	99.6	9,914	97.82	102.6	111	97	1,081,084	1,040,369	18,966	18,433	0.02	690
3.3	100.4	10,074	97.84	102.7	112	96	1,091,158	1,030,296	18,973	18,271	0.02	775
3.29	90.9	8,255	97.78	102.7	113	95	1,099,413	1,022,041	19,021	20,089	-0.03	683
3.3	100.4	10,074	97.8	102.8	114	94	1,109,486	1,011,967	19,028	18,154	0.02	726
3.35	86.5	7,487	97.7	102.8	115	93	1,116,973	1,004,480	19,154	20,740	-0.05	776

P [g/kg]; last value included in population 1	Xi=rel. cotton production [%]	Xi^2	mean(Xi1)	mean(Xi2)	n(Xi1)	n(Xi2)	Summe $Xi1^2$	Summe $Xi2^2$	CSS1	CSS2	R^2 for postulated critical level	Farm no.
3.35	108.2	11,699	97.8	103	116	92	1,128,673	992,781	19,262	16,295	0.06	712
3.36	86.0	7,404	97.69	103	117	91	1,136,077	985,376	19,399	20,551	-0.05	753
3.4	100.4	10,074	97.72	103.2	118	90	1,146,151	975,303	19,406	17,631	0.03	771
3.37	94.9	9,014	97.69	103.2	119	89	1,155,164	966,289	19,414	18,690	0.00	761
3.4	94.8	8,985	97.67	103.3	120	88	1,164,150	957,304	19,422	18,668	0.00	735
3.37	90.1	8,124	97.61	103.4	121	87	1,172,274	949,180	19,478	19,476	-0.03	757
3.40	68.7	4,719	97.37	103.5	122	86	1,176,993	944,460	20,307	22,736	-0.13	754
3.40	101.4	10,282	97.4	103.9	123	85	1,187,276	934,178	20,323	16,029	0.04	273
3.41	90.9	8,255	97.35	104	124	84	1,195,531	925,923	20,366	18,057	-0.01	488
3.42	107.6	11,586	97.43	104.1	125	83	1,207,117	914,337	20,471	14,584	0.08	688
3.45	94.4	8,919	97.41	104.1	126	82	1,216,036	905,418	20,480	17,230	0.01	679
3.5	117.9	13,898	97.57	104.2	127	81	1,229,934	891,519	20,896	12,181	0.13	737
3.5	104.9	11,000	97.63	104	128	80	1,240,934	880,519	20,949	14,854	0.06	786
3.5	77.5	6,003	97.47	104	129	79	1,246,937	874,517	21,352	19,849	-0.08	273
3.49	104.9	11,011	97.53	104.3	130	78	1,257,948	863,505	21,407	14,197	0.06	333
3.49	118.9	14,143	97.69	104.3	131	77	1,272,091	849,362	21,862	11,063	0.13	690
3.5	89.2	7,959	97.63	104.2	132	76	1,280,050	841,403	21,933	16,992	-0.02	774
3.5	99.8	9,956	97.64	104.3	133	75	1,290,007	831,447	21,938	14,810	0.03	776
3.55	102.8	10,575	97.68	104.4	134	74	1,300,582	820,872	21,964	14,183	0.05	36
3.5	119.6	14,298	97.84	104.4	135	73	1,314,879	806,574	22,440	10,462	0.13	739
3.55	111.5	12,430	97.95	104.2	136	72	1,327,310	794,144	22,625	12,053	0.09	266
3.6	102.3	10,461	97.98	104.1	137	71	1,337,771	783,683	22,643	13,948	0.04	744
3.6	133.8	17,909	98.24	104.1	138	70	1,355,679	765,774	23,919	6,503	0.20	266
3.58	104.9	11,011	98.28	103.7	139	69	1,366,690	754,763	23,964	12,419	0.04	683
3.59	75.7	5,733	98.12	103.7	140	68	1,372,423	749,031	24,469	17,692	-0.11	756
3.59	112.6	12,668	98.23	104.1	141	67	1,385,091	736,362	24,676	10,047	0.09	740
3.60	124.2	15,428	98.41	104	142	66	1,400,519	720,934	25,347	7,188	0.14	739
3.60	108.2	11,699	98.48	103.7	143	65	1,412,219	709,235	25,441	10,439	0.06	761
3.61	102.5	10,500	98.5	103.6	144	64	1,422,719	698,735	25,457	11,604	0.02	266
3.7	104.3	10,884	98.54	103.6	145	63	1,433,602	687,851	25,491	11,222	0.03	763
3.67	104.5	10,922	98.59	103.6	146	62	1,444,524	676,930	25,526	11,181	0.03	763
3.69	102.5	10,500	98.61	103.6	147	61	1,455,024	666,430	25,541	11,599	0.02	266
3.7	100.4	10,074	98.62	103.6	148	60	1,465,097	656,356	25,544	12,028	0.01	736
3.7	125.5	15,740	98.8	103.7	149	59	1,480,837	640,616	26,259	6,363	0.14	163
3.71	73.5	5,395	98.64	103.3	150	58	1,486,233	635,221	26,898	16,148	-0.13	769
3.71	83.9	7,047	98.54	103.8	151	57	1,493,280	628,174	27,112	13,696	-0.07	760
3.73	86.5	7,487	98.46	104.2	152	56	1,500,767	620,686	27,255	12,926	-0.06	7822
3.74	108.2	11,699	98.52	104.5	153	55	1,512,466	608,987	27,349	8,464	0.06	692
3.75	83.6	6,982	98.43	104.4	154	54	1,519,449	602,005	27,571	13,152	-0.07	762
3.76	94.4	8,919	98.4	104.8	155	53	1,528,368	593,086	27,587	10,853	-0.01	770
3.79	97.3	9,476	98.39	105	156	52	1,537,844	583,609	27,588	10,228	0.00	163
3.79	108.2	11,699	98.45	105.2	157	51	1,549,543	571,910	27,683	7,976	0.06	764
3.80	101.4	10,282	98.47	105.1	158	50	1,559,825	561,628	27,691	9,371	0.02	273
3.82	86.5	7,487	98.4	105.2	159	49	1,567,313	554,141	27,833	12,168	-0.05	758
3.8	111.5	12,436	98.48	105.6	160	48	1,579,749	541,704	28,004	6,944	0.08	761
3.85	125.9	15,856	98.65	105.4	161	47	1,595,605	525,848	28,752	3,462	0.15	727
3.85	108.2	11,699	98.71	105	162	46	1,607,304	514,149	28,842	7,098	0.05	772
3.85	113.4	12,869	98.8	104.9	163	45	1,620,173	501,280	29,058	5,904	0.08	729
3.85	108.2	11,699	98.86	104.7	164	44	1,631,873	489,581	29,145	6,960	0.05	762
3.85	94.4	8,919	98.83	104.7	165	43	1,640,792	480,662	29,165	9,711	-0.02	756
3.86	97.3	9,476	98.82	104.9	166	42	1,650,268	471,186	29,167	9,097	-0.01	696
3.87	94.4	8,919	98.8	105.1	167	41	1,659,187	462,267	29,186	9,634	-0.02	775
3.87	113.7	12,923	98.88	105.3	168	40	1,672,109	449,344	29,406	5,569	0.08	786
3.88	113.7	12,923	98.97	105.1	169	39	1,685,032	436,421	29,624	5,453	0.08	730
3.93	87.6	7,681	98.9	104.9	170	38	1,692,713	428,741	29,751	10,574	-0.06	680
4.0	111.5	12,436	98.98	105.4	171	37	1,705,149	416,304	29,909	5,608	0.07	764
4.0	83.6	6,996	98.89	105.2	172	36	1,712,145	409,309	30,143	10,975	-0.08	680
4.00	108.2	11,699	98.94	105.8	173	35	1,723,844	397,610	30,229	5,921	0.05	773
4.04	94.4	8,919	98.92	105.7	174	34	1,732,763	388,691	30,249	8,680	-0.02	773
4.06	86.5	7,487	98.85	106.1	175	33	1,740,250	381,203	30,402	10,051	-0.06	7821

P [g/kg]; last value included in population 1	Xi=rel. cotton production [%]	Xi^2	mean(Xi1)	mean(Xi2)	n(Xi1)	n(Xi2)	Summe $Xi1^2$	Summe $Xi2^2$	CSS1	CSS2	R^2 for postulated critical level	Farm no.
4.09	104.9	11,011	98.88	106.6	176	32	1,751,261	370,192	30,438	6,261	0.03	757
4.11	91.9	8,453	98.84	106.7	177	31	1,759,714	361,739	30,486	8,828	-0.03	680
4.15	111.5	12,430	98.91	107.2	178	30	1,772,144	349,309	30,646	4,727	0.07	741
4.16	104.9	11,011	98.95	107	179	29	1,783,156	338,298	30,682	6,096	0.03	771
4.18	131.2	17,205	99.13	107.1	180	28	1,800,360	321,093	31,714	-87	0.17	785
4.19	94.4	8,919	99.1	106.2	181	27	1,809,279	312,174	31,736	7,416	-0.03	765
4.20	120.7	14,562	99.22	106.7	182	26	1,823,841	297,612	32,199	1,721	0.11	743
4.24	119.9	14,382	99.33	106.1	183	25	1,838,223	283,230	32,625	1,584	0.10	788
4.25	108.2	11,699	99.38	105.6	184	24	1,849,922	271,531	32,703	3,952	0.04	308
4.27	102.2	10,435	99.39	105.5	185	23	1,860,358	261,096	32,710	5,186	0.00	685
4.28	94.4	8,919	99.37	105.6	186	22	1,869,277	252,177	32,735	6,722	-0.04	772
4.28	131.2	17,205	99.54	106.1	187	21	1,886,481	234,972	33,741	-1,587	0.15	732
4.35	97.3	9,476	99.53	104.9	188	20	1,895,958	225,496	33,745	5,233	-0.03	679
4.35	104.9	11,011	99.55	105.3	189	19	1,906,969	214,485	33,774	3,718	0.01	689
4.42	104.9	11,011	99.58	105.3	190	18	1,917,980	203,474	33,803	3,722	0.01	776
4.42	122.4	14,987	99.7	105.4	191	17	1,932,967	188,486	34,322	-250	0.10	541
4.5	99.1	9,826	99.7	104.4	192	16	1,942,794	178,660	34,323	4,393	-0.02	762
4.5	133.8	17,909	99.88	104.7	193	15	1,960,702	160,751	35,481	-3,650	0.16	36
4.52	108.6	11,784	99.92	102.7	194	14	1,972,486	148,968	35,556	1,167	0.03	734
4.6	100.4	10,074	99.92	102.3	195	13	1,982,559	138,894	35,556	2,756	-0.01	756
4.66	121.1	14,660	100	102.5	196	12	1,997,219	124,235	36,001	-1,804	0.10	725
4.70	109.1	11,910	100.1	100.9	197	11	2,009,129	112,325	36,084	257	0.04	733
4.79	119.2	14,219	100.2	100.2	198	10	2,023,347	98,106	36,449	-2,276	0.10	728
4.80	83.9	7,047	100.1	98.29	199	9	2,030,394	91,059	36,711	4,119	-0.07	777
4.9	89.2	7,959	100	99.88	200	8	2,038,354	83,100	36,829	3,294	-0.06	679
4.9	78.1	6,094	99.93	101.2	201	7	2,044,448	77,006	37,309	5,299	-0.12	755
4.95	111.6	12,462	99.99	104.5	202	6	2,056,909	64,544	37,446	-1,001	0.04	745
4.98	115.4	13,323	100.1	103.3	203	5	2,070,233	51,221	37,683	-2,168	0.07	163
5.0	100.4	10,074	100.1	100.9	204	4	2,080,306	41,147	37,683	413	0.00	758
5.16	104.9	11,011	100.1	101.1	205	3	2,091,317	30,136	37,706	-498	0.02	735
5.27	104.9	11,011	100.1	99.76	206	2	2,102,328	19,125	37,730	-778	0.03	724
5.3	86.2	7,426	100	97.17	207	1	2,109,754	11,699	37,923	2,257	-0.06	757
5.47	108.2	11,699	100.1	108.2	208	0	2,121,453	2,143,352	37,989	2,143,352	-56.42	770
Summe	**100.1**	**10,199.3**										

Tab. 8.22: Cumulative variance ratios (VN) for plant nutrients of organically grown Egyptian cotton (*Gossypium barbadense*) according to Khiari et al., (2001a).

Farm no.	Rel. Production	C	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo	R^2
36	134														
266	134	0.55	0.54	0.01	0.07	0.23	0.12	0.99	1.06	0.25	0.04	0.75	0.04	0.49	0.48
732	131	1.11	1.40	0.14	0.11	0.81	0.68	3.55	1.84	0.39	0.15	1.14	0.30	0.83	1.23
785	131	2.34	2.40	0.33	0.15	1.32	1.07	5.48	2.52	0.50	0.31	2.18	0.49	1.17	2.48
727	126	3.38	3.16	0.51	0.45	1.75	1.43	7.20	3.46	0.61	0.43	3.10	0.95	1.84	3.49
688	126	4.24	3.77	0.69	0.70	2.09	1.83	8.59	4.32	0.76	0.53	4.16	1.34	2.47	4.31
163	125	4.97	4.27	0.84	0.99	2.38	2.21	9.75	5.06	0.89	0.61	5.11	1.69	3.03	5.00
685	125	5.60	4.71	1.02	1.24	2.65	2.61	10.74	5.75	1.03	0.69	6.08	2.00	3.55	5.58
739	124	6.17	5.10	1.17	1.46	2.88	2.97	11.60	6.35	1.17	0.80	7.01	2.28	4.01	6.12
308	124	6.67	5.44	1.33	1.66	3.10	3.34	12.37	6.89	1.31	0.92	7.85	2.52	4.44	6.60
686	123	7.13	5.76	1.48	1.85	3.29	3.67	13.10	7.41	1.63	1.02	8.62	2.74	4.82	7.03
541	122	7.54	6.17	1.65	2.03	3.47	4.02	13.77	7.91	1.93	1.23	9.32	2.94	5.18	7.43
685	121	7.94	6.57	1.98	2.20	3.64	4.42	14.44	8.36	2.26	1.45	10.44	3.53	5.50	7.80

Farm no.	Rel. Pro-duction	C	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo	R^2
725	121	8.32	6.94	2.35	2.36	3.93	4.92	15.22	8.81	2.62	1.66	11.49	4.10	5.80	8.15
743	121	8.79	7.37	2.75	2.51	4.28	5.48	16.11	9.27	2.97	1.85	12.48	4.66	6.09	8.64
788	120	9.30	7.77	3.18	2.67	4.66	6.13	17.10	9.71	3.29	2.03	13.44	5.18	6.36	9.21
739	120	9.78	8.14	3.57	2.82	5.02	6.74	18.03	10.13	3.61	2.20	14.40	5.68	6.63	9.75
728	119	10.28	8.55	3.96	2.97	5.38	7.33	19.04	10.58	3.92	2.41	15.34	6.24	6.89	10.30
690	119	10.76	8.93	4.32	3.10	5.72	7.91	20.03	11.01	4.36	2.61	16.26	6.77	7.15	10.82
737	118	11.22	9.29	4.66	3.24	6.05	8.46	20.97	11.43	4.78	2.81	17.17	7.28	7.39	11.31
725	117	11.74	9.84	5.15	3.37	6.37	9.08	21.90	11.87	5.19	3.15	18.05	7.80	7.65	11.82
541	116	12.25	10.35	5.62	3.52	6.68	9.70	22.79	12.30	5.59	3.49	18.95	8.30	7.91	12.32
677	116	12.82	10.90	6.13	3.67	6.98	10.29	23.65	12.72	6.20	3.87	20.03	8.89	8.16	12.86
163	115	13.36	11.48	6.66	3.81	7.28	10.86	24.50	13.14	6.79	4.38	21.05	9.48	8.40	13.38
787	114	14.02	12.25	7.26	3.96	7.56	11.45	25.33	13.58	7.36	4.97	22.05	10.12	8.64	13.95
710	114	14.66	13.00	7.84	4.11	7.88	12.10	26.19	14.02	7.97	5.54	23.01	10.74	8.88	14.55
786	114	15.28	13.72	8.41	4.26	8.19	12.73	27.01	14.43	8.54	6.10	23.94	11.35	9.11	15.12
729	113	15.91	14.41	8.95	4.46	8.51	13.38	27.82	14.95	9.12	6.64	24.86	12.02	9.44	15.71
740	113	16.52	15.08	9.47	4.67	8.82	14.02	28.59	15.44	9.77	7.16	25.78	12.66	9.75	16.27
308	112	17.10	15.73	9.97	4.88	9.13	14.64	29.34	15.92	10.40	7.66	26.68	13.31	10.08	16.81
736	112	17.67	16.36	10.47	5.09	9.44	15.23	30.08	16.38	11.05	8.16	27.54	13.93	10.39	17.33
745	112	18.22	16.99	10.99	5.30	9.73	15.81	30.79	16.83	11.67	8.65	28.37	14.55	10.71	17.83
732	112	18.76	17.61	11.49	5.51	10.01	16.38	31.49	17.26	12.28	9.14	29.18	15.14	11.02	18.32
753	112	19.31	18.21	11.97	5.73	10.30	16.96	32.18	17.71	12.86	9.62	29.95	15.72	11.36	18.80
761	112	19.89	18.78	12.46	5.96	10.60	17.52	32.84	18.15	13.43	10.08	30.70	16.28	11.72	19.29
764	112	20.45	19.37	12.92	6.23	10.95	18.09	33.50	18.68	13.97	10.55	31.42	16.84	12.12	19.77
772	112	21.02	19.95	13.37	6.49	11.31	18.66	34.13	19.20	14.50	11.00	32.13	17.39	12.53	20.24
789	112	21.58	20.51	13.82	6.74	11.66	19.22	34.75	19.71	15.01	11.48	32.81	18.00	12.94	20.70
266	111	22.12	21.07	14.25	6.99	12.00	19.77	35.35	20.20	15.51	11.95	33.48	18.60	13.34	21.15
741	111	22.66	21.61	14.68	7.23	12.32	20.29	35.93	20.68	16.00	12.41	34.13	19.22	13.74	21.59
729	110	23.17	22.14	15.11	7.46	12.64	20.83	36.49	21.14	16.47	12.87	34.76	19.84	14.13	22.01
733	109	23.68	22.66	15.56	7.69	12.96	21.35	37.05	21.59	16.92	13.33	35.38	20.45	14.52	22.44
743	109	24.17	23.16	15.99	7.92	13.26	21.85	37.60	22.04	17.39	13.78	35.98	21.05	14.93	22.85
734	109	24.66	23.70	16.44	8.14	13.56	22.35	38.15	22.49	17.84	14.23	36.56	21.64	15.32	23.25
163	108	25.13	24.23	16.88	8.36	13.85	22.84	38.68	22.92	18.33	14.68	37.13	22.22	15.72	23.65
308	108	25.59	24.77	17.30	8.58	14.14	23.31	39.22	23.34	18.81	15.13	37.70	22.79	16.11	24.07
692	108	26.05	25.29	17.71	8.79	14.44	23.78	39.74	23.75	19.28	15.57	38.25	23.34	16.50	24.48
692	108	26.49	25.80	18.12	8.99	14.77	24.24	40.25	24.15	19.74	16.00	38.80	23.88	16.88	24.87
692	108	26.92	26.31	18.52	9.19	15.13	24.68	40.75	24.54	20.19	16.42	39.33	24.41	17.26	25.26
712	108	27.36	26.80	18.92	9.40	15.48	25.12	41.24	24.93	20.65	16.83	39.85	24.93	17.63	25.64
721	108	27.78	27.29	19.30	9.60	15.84	25.55	41.72	25.31	21.10	17.22	40.36	25.44	18.02	26.02
726	108	28.20	27.76	19.69	9.79	16.19	25.96	42.21	25.69	21.56	17.61	40.85	25.94	18.41	26.39
728	108	28.61	28.22	20.08	9.98	16.54	26.38	42.69	26.07	22.02	18.00	41.34	26.43	18.81	26.75
729	108	29.01	28.67	20.45	10.17	16.88	26.78	43.16	26.45	22.48	18.37	41.81	26.90	19.22	27.10
732	108	29.41	29.11	20.82	10.35	17.22	27.17	43.63	26.83	22.93	18.74	42.27	27.36	19.63	27.44
759	108	29.80	29.56	21.21	10.56	17.55	27.61	44.10	27.20	23.38	19.14	42.73	27.89	20.06	27.78
761	108	30.18	30.01	21.59	10.79	17.90	28.04	44.55	27.58	23.83	19.55	43.17	28.40	20.48	28.11
762	108	30.56	30.45	21.97	11.05	18.24	28.47	44.99	27.95	24.28	19.98	43.62	28.90	20.90	28.43
770	108	30.93	30.88	22.35	11.36	18.70	28.97	45.53	28.36	24.72	20.40	44.05	29.47	21.31	28.76
772	108	31.29	31.31	22.73	11.69	19.16	29.45	46.05	28.76	25.16	20.81	44.47	30.03	21.73	29.08
773	108	31.65	31.73	23.10	12.04	19.63	29.93	46.57	29.17	25.59	21.21	44.89	30.58	22.13	29.42
784	108	32.00	32.14	23.46	12.38	20.10	30.40	47.08	29.56	26.02	21.61	45.30	31.12	22.54	29.75
786	108	32.34	32.54	23.81	12.71	20.56	30.86	47.58	29.97	26.46	21.99	45.70	31.64	22.96	30.07
788	108	32.68	32.94	24.17	13.03	21.03	31.31	48.09	30.38	26.90	22.37	46.10	32.16	23.38	30.39
728	108	33.01	33.33	24.51	13.35	21.50	31.77	48.59	30.77	27.35	22.77	46.49	32.66	23.81	30.70
688	108	33.33	33.71	24.86	13.66	21.96	32.23	49.07	31.17	27.78	23.16	46.88	33.16	24.23	31.01
488	107	33.65	34.08	25.25	13.97	22.41	32.71	49.55	31.56	28.26	23.57	47.25	33.71	24.65	31.32
768	106	33.98	34.54	25.65	14.29	22.89	33.23	50.03	32.09	28.73	23.97	47.63	34.27	25.11	31.64
721	106	34.31	35.00	26.04	14.61	23.38	33.75	50.49	32.62	29.19	24.37	48.00	34.88	25.59	31.95
682	106	34.63	35.44	26.43	14.93	23.87	34.26	50.95	33.15	29.65	24.76	48.41	35.48	26.06	32.25
710	105	34.94	35.87	26.81	15.25	24.35	34.77	51.40	33.68	30.10	25.15	48.82	36.06	26.54	32.55
152	105	35.24	36.30	27.19	15.57	24.84	35.28	51.84	34.21	30.55	25.53	49.22	36.64	27.02	32.84
256	105	35.54	36.72	27.58	15.94	25.34	35.80	52.28	34.74	31.00	25.90	49.62	37.21	27.50	33.13
311	105	35.85	37.14	28.03	16.30	25.83	36.31	52.72	35.29	31.47	26.29	50.04	37.80	27.98	33.42

Farm no.	Rel. Production	C	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo	R^2
683	105	36.16	37.59	28.48	16.67	26.31	36.86	53.18	35.82	31.93	26.68	50.46	38.37	28.46	33.71
686	105	36.48	38.04	28.92	17.04	26.78	37.40	53.65	36.35	32.41	27.06	50.88	38.94	28.93	34.00
689	105	36.79	38.47	29.36	17.41	27.25	37.94	54.10	36.87	32.89	27.44	51.30	39.50	29.39	34.28
724	105	37.17	38.90	29.87	17.79	27.72	38.48	54.55	37.40	33.38	27.85	51.71	40.05	29.86	34.65
735	105	37.62	39.33	30.45	18.16	28.21	39.00	55.00	37.95	33.87	28.30	52.11	40.60	30.35	35.10
757	105	38.08	39.77	31.04	18.53	28.69	39.52	55.46	38.49	34.39	28.73	52.51	41.14	30.82	35.56
759	105	38.52	40.20	31.62	18.89	29.16	40.03	55.92	39.04	34.90	29.16	52.92	41.68	31.31	36.00
764	105	38.96	40.62	32.18	19.25	29.64	40.53	56.37	39.58	35.42	29.57	53.34	42.21	31.80	36.44
771	105	39.39	41.04	32.75	19.60	30.10	41.02	56.81	40.11	35.95	30.00	53.76	42.74	32.27	36.88
776	105	39.81	41.47	33.32	19.95	30.56	41.50	57.25	40.64	36.49	30.42	54.17	43.26	32.73	37.30
786	105	40.23	41.90	33.88	20.30	31.02	41.99	57.71	41.16	37.02	30.83	54.58	43.79	33.19	37.72
763	105	40.64	42.34	34.43	20.65	31.47	42.47	58.15	41.68	37.54	31.23	54.98	44.32	33.67	38.14
763	104	41.05	42.77	34.97	21.04	31.93	42.97	58.59	42.23	38.06	31.63	55.38	44.84	34.15	38.55
789	103	41.45	43.19	35.50	21.43	32.39	43.46	59.04	42.78	38.57	32.02	55.78	45.35	34.62	38.96
790	103	41.85	43.61	36.03	21.82	32.85	43.95	59.48	43.33	39.07	32.40	56.18	45.86	35.10	39.35
787	103	42.23	44.02	36.55	22.19	33.31	44.42	59.92	43.88	39.57	32.78	56.57	46.35	35.59	39.75
36	103	42.63	44.44	37.05	22.58	33.78	44.88	60.35	44.42	40.08	33.18	56.96	46.84	36.08	40.14
785	103	43.05	44.89	37.56	22.97	34.26	45.35	60.77	44.96	40.58	33.60	57.35	47.43	36.57	40.55
725	103	43.48	45.33	38.06	23.35	34.73	45.81	61.18	45.49	41.07	34.02	57.74	48.01	37.06	40.96
760	103	43.90	45.77	38.57	23.73	35.20	46.28	61.59	46.01	41.56	34.45	58.12	48.59	37.55	41.37
760	103	44.32	46.20	39.07	24.11	35.67	46.74	62.00	46.54	42.08	34.88	58.49	49.18	38.03	41.79
266	102	44.73	46.63	39.56	24.49	36.12	47.21	62.45	47.07	42.59	35.32	58.86	49.77	38.50	42.20
266	102	45.14	47.04	40.04	24.86	36.57	47.68	62.93	47.59	43.09	35.76	59.23	50.35	38.97	42.61
266	102	45.55	47.46	40.52	25.23	37.02	48.16	63.41	48.11	43.60	36.21	59.60	50.92	39.43	43.00
744	102	45.94	47.86	40.98	25.60	37.45	48.64	63.89	48.62	44.10	36.66	59.96	51.48	39.88	43.39
685	102	46.34	48.27	41.44	25.96	37.88	49.11	64.36	49.13	44.60	37.09	60.32	52.04	40.33	43.79
273	101	46.73	48.67	41.90	26.32	38.32	49.57	64.83	49.63	45.09	37.53	60.67	52.58	40.77	44.17
273	101	47.11	49.07	42.36	26.67	38.75	50.02	65.30	50.12	45.58	37.96	61.01	53.12	41.21	44.56
273	101	47.48	49.47	42.80	27.02	39.17	50.46	65.77	50.61	46.06	38.38	61.35	53.65	41.67	44.93
689	101	47.85	49.87	43.24	27.36	39.58	50.90	66.23	51.09	46.53	38.80	61.69	54.18	42.12	45.30
688	101	48.21	50.27	43.67	27.70	39.99	51.33	66.68	51.56	47.00	39.21	62.02	54.72	42.57	45.67
724	100	48.57	50.69	44.10	28.03	40.39	51.77	67.14	52.03	47.47	39.64	62.34	55.24	43.02	46.03
726	100	48.93	51.10	44.53	28.36	40.80	52.22	67.59	52.49	47.93	40.06	62.66	55.76	43.49	46.39
734	100	49.29	51.51	44.95	28.69	41.21	52.67	68.03	52.96	48.38	40.47	63.00	56.26	43.95	46.74
736	100	49.64	51.92	45.37	29.03	41.62	53.12	68.47	53.45	48.82	40.88	63.34	56.77	44.41	47.09
754	100	50.01	52.32	45.78	29.36	42.02	53.57	68.90	53.93	49.26	41.29	63.67	57.27	44.87	47.45
756	100	50.38	52.72	46.19	29.74	42.45	54.06	69.33	54.47	49.69	41.69	64.00	57.79	45.34	47.81
758	100	50.75	53.11	46.59	30.19	42.92	54.56	69.76	55.06	50.12	42.08	64.32	58.30	45.81	48.20
769	100	51.14	53.50	46.99	30.63	43.39	55.06	70.18	55.65	50.54	42.46	64.64	58.81	46.28	48.59
771	100	51.53	53.89	47.38	31.07	43.85	55.56	70.59	56.24	50.95	42.84	64.95	59.32	46.77	48.98
775	100	51.95	54.26	47.77	31.50	44.30	56.08	71.00	56.82	51.36	43.21	65.26	59.82	47.27	49.38
784	100	52.35	54.64	48.16	31.93	44.75	56.60	71.40	57.39	51.77	43.58	65.57	60.32	47.77	49.77
776	100	52.79	55.00	48.54	32.36	45.19	57.13	71.80	57.95	52.17	43.94	65.87	60.81	48.28	50.18
690	100	53.22	55.37	48.92	32.78	45.62	57.65	72.19	58.53	52.55	44.29	66.20	61.30	48.79	50.58
762	99	53.64	55.73	49.30	33.22	46.07	58.16	72.57	59.09	52.94	44.71	66.52	61.79	49.32	50.98
241	99	54.05	56.08	49.67	33.65	46.51	58.66	72.95	59.65	53.32	45.13	66.85	62.30	49.84	51.37
205	99	54.47	56.43	50.06	34.10	46.94	59.16	73.34	60.19	53.71	45.53	67.17	62.82	50.35	51.78
6772	98	54.90	56.79	50.49	34.54	47.37	59.66	73.73	60.74	54.10	45.93	67.49	63.37	50.87	52.20
292	97	55.34	57.14	50.93	34.97	47.87	60.17	74.12	61.29	54.49	46.33	67.80	63.94	51.38	52.62
679	97	55.77	57.52	51.37	35.41	48.36	60.68	74.50	61.82	54.90	46.72	68.11	64.51	51.89	53.04
696	97	56.24	57.89	51.81	35.85	48.88	61.17	74.87	62.34	55.31	47.12	68.42	65.06	52.43	53.50
696	97	56.73	58.26	52.25	36.28	49.41	61.66	75.26	62.86	55.72	47.51	68.77	65.61	52.96	53.97
764	97	57.20	58.62	52.69	36.73	49.94	62.15	75.64	63.36	56.13	47.89	69.15	66.14	53.48	54.43
785	97	57.67	58.97	53.12	37.17	50.48	62.62	76.02	63.88	56.53	48.27	69.52	66.67	54.02	54.87
778	97	58.13	59.32	53.54	37.60	51.03	63.09	76.39	64.38	56.93	48.65	69.88	67.19	54.55	55.32
710	97	58.58	59.66	53.95	38.02	51.57	63.55	76.76	64.87	57.32	49.02	70.24	67.70	55.09	55.75
457	97	59.03	60.01	54.43	38.44	52.11	64.00	77.13	65.37	57.71	49.39	70.61	68.21	55.61	56.17
241	96	59.47	60.36	54.89	38.85	52.63	64.49	77.49	65.87	58.09	49.76	70.97	68.73	56.13	56.59
724	95	59.92	60.69	55.35	39.26	53.19	64.97	77.86	66.36	58.47	50.12	71.33	69.23	56.66	57.00
761	95	60.36	61.03	55.80	39.65	53.74	65.43	78.21	66.84	58.84	50.48	71.69	69.73	57.19	57.41
735	95	60.80	61.37	56.25	40.04	54.30	65.89	78.56	67.35	59.21	50.83	72.11	70.23	57.73	57.81

Farm no.	Rel. Pro-duction	C	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo	R^2
740	95	61.24	61.70	56.69	40.45	54.89	66.37	78.91	67.88	59.57	51.17	72.59	70.72	58.26	58.21
770	95	61.68	62.03	57.12	40.85	55.47	66.85	79.24	68.41	59.92	51.50	73.06	71.20	58.81	58.61
679	94	62.13	62.37	57.55	41.27	56.06	67.32	79.57	68.92	60.27	51.83	73.52	71.68	59.35	59.01
2	94	62.57	62.70	58.00	41.70	56.80	67.79	79.92	69.43	60.63	52.16	73.97	72.16	59.89	59.41
205	94	63.02	63.02	58.47	42.12	57.54	68.24	80.28	69.92	61.00	52.48	74.45	72.63	60.42	59.81
258	94	63.46	63.35	58.95	42.54	58.26	68.70	80.63	70.42	61.37	52.80	74.91	73.11	60.98	60.20
666	94	63.90	63.69	59.42	42.95	58.97	69.14	80.98	70.92	61.74	53.11	75.41	73.62	61.55	60.59
754	94	64.35	64.03	59.89	43.35	59.67	69.58	81.36	71.42	62.10	53.42	75.90	74.13	62.12	61.00
756	94	64.79	64.39	60.36	43.75	60.36	70.02	81.73	71.92	62.46	53.72	76.38	74.63	62.69	61.40
765	94	65.25	64.79	60.84	44.14	61.06	70.45	82.11	72.41	62.81	54.02	76.85	75.13	63.24	61.81
770	94	65.70	65.18	61.32	44.54	61.74	70.88	82.48	72.90	63.16	54.31	77.31	75.62	63.79	62.21
772	94	66.15	65.57	61.81	44.92	62.41	71.29	82.84	73.38	63.51	54.60	77.77	76.11	64.33	62.62
773	94	66.60	65.95	62.32	45.30	63.07	71.69	83.19	73.87	63.86	54.89	78.22	76.60	64.85	63.03
775	94	67.04	66.34	62.82	45.69	63.71	72.09	83.55	74.34	64.21	55.17	78.67	77.08	65.36	63.43
205	94	67.47	66.72	63.32	46.07	64.34	72.47	83.92	74.81	64.56	55.45	79.10	77.55	65.86	63.82
682	94	67.89	67.09	63.80	46.45	64.97	72.86	84.28	75.26	64.92	55.74	79.55	78.03	66.36	64.21
680	92	68.31	67.52	64.29	46.82	65.63	73.25	84.64	75.76	65.30	56.02	79.99	78.50	66.87	64.58
727	92	68.71	67.93	64.77	47.19	66.32	73.63	85.01	76.27	65.68	56.29	80.42	78.96	67.40	64.95
488	91	69.10	68.34	65.23	47.54	67.02	74.03	85.37	76.76	66.05	56.59	80.84	79.42	67.91	65.31
683	91	69.49	68.74	65.68	47.90	67.71	74.42	85.73	77.27	66.41	56.89	81.25	79.87	68.47	65.68
757	90	69.87	69.16	66.13	48.29	68.38	74.80	86.08	77.76	66.78	57.18	81.65	80.32	69.02	66.03
766	90	70.26	69.57	66.56	48.68	69.04	75.18	86.44	78.25	67.14	57.47	82.04	80.76	69.58	66.39
679	89	70.66	69.98	66.99	49.05	69.71	75.55	86.83	78.75	67.49	57.75	82.42	81.20	70.18	66.76
318	89	71.04	70.39	67.46	49.42	70.36	75.91	87.21	79.25	67.86	58.04	82.80	81.68	70.77	67.13
692	89	71.42	70.79	67.91	49.78	70.99	76.26	87.58	79.73	68.23	58.31	83.17	82.15	71.34	67.49
696	89	71.79	71.18	68.35	50.13	71.63	76.61	87.95	80.20	68.58	58.59	83.55	82.61	71.95	67.83
759	89	72.14	71.58	68.78	50.50	72.27	76.99	88.31	80.77	68.93	58.86	83.93	83.08	72.56	68.17
760	89	72.49	71.97	69.20	50.85	72.89	77.36	88.65	81.33	69.26	59.13	84.30	83.55	73.19	68.50
774	89	72.86	72.35	69.62	51.21	73.51	77.75	88.99	81.87	69.59	59.39	84.67	84.01	73.83	68.84
777	89	73.27	72.73	70.04	51.57	74.13	78.15	89.32	82.40	69.91	59.65	85.03	84.48	74.52	69.19
790	89	73.67	73.09	70.45	51.92	74.73	78.55	89.65	82.92	70.22	59.90	85.39	84.95	75.22	69.54
680	88	74.10	73.50	70.88	52.25	75.36	78.95	89.97	83.47	70.58	60.16	85.74	85.41	75.90	69.92
444	87	74.52	73.90	71.30	52.58	76.00	79.33	90.29	84.00	70.93	60.41	86.08	85.88	76.56	70.29
677	87	74.95	74.29	71.71	52.90	76.62	79.73	90.62	84.52	71.29	60.65	86.42	86.34	77.22	70.67
736	87	75.38	74.69	72.11	53.21	77.22	80.13	90.93	85.03	71.70	60.89	86.76	86.79	77.89	71.05
736	87	75.79	75.08	72.50	53.51	77.81	80.51	91.24	85.52	72.14	61.13	87.09	87.22	78.56	71.41
753	87	76.20	75.51	72.87	53.81	78.37	80.89	91.55	86.01	72.57	61.35	87.43	87.65	79.20	71.77
758	87	76.61	75.93	73.24	54.09	78.96	81.26	91.85	86.52	73.00	61.70	87.75	88.06	79.85	72.12
775	87	77.00	76.37	73.59	54.40	79.54	81.62	92.14	87.03	73.42	62.04	88.07	88.46	80.51	72.47
776	87	77.42	76.84	73.94	54.71	80.10	81.98	92.44	87.52	73.83	62.39	88.38	88.85	81.16	72.83
6771	87	77.93	77.35	74.33	55.01	80.64	82.41	92.78	88.02	74.30	62.99	88.70	89.22	81.78	73.29
7821	87	78.44	77.88	74.74	55.30	81.21	82.83	93.10	88.51	74.82	63.56	89.01	89.60	82.40	73.77
7822	87	78.97	78.40	75.16	55.59	81.81	83.23	93.41	88.99	75.42	64.12	89.33	89.97	83.03	74.28
757	86	79.50	78.91	75.61	55.89	82.45	83.64	93.72	89.48	76.03	64.68	89.64	90.35	83.68	74.78
753	86	80.01	79.44	76.05	56.18	83.06	84.05	94.02	89.98	76.63	65.22	89.94	90.73	84.30	75.27
292	84	80.51	79.95	76.55	56.47	83.80	84.47	94.30	90.46	77.20	65.74	90.25	91.10	84.98	75.74
318	84	80.98	80.45	77.04	56.74	84.51	84.87	94.60	90.93	77.76	66.24	90.56	91.48	85.64	76.19
488	84	81.44	80.93	77.51	57.01	85.20	85.25	94.91	91.37	78.30	66.73	90.87	91.88	86.26	76.62
755	84	81.93	81.46	77.97	57.26	85.86	85.62	95.22	91.81	78.88	67.20	91.17	92.26	86.86	77.09
760	84	82.41	82.02	78.43	57.51	86.49	85.97	95.52	92.23	79.45	67.66	91.46	92.65	87.47	77.55
768	84	83.05	82.67	78.88	57.76	87.10	86.31	95.81	92.63	79.98	68.12	91.74	93.02	88.09	78.21
774	84	83.72	83.30	79.31	58.01	87.67	86.63	96.08	93.01	80.51	68.63	92.02	93.37	88.76	78.96
777	84	84.38	83.90	79.81	58.25	88.23	86.93	96.35	93.37	81.06	69.76	92.29	93.77	89.46	79.70
680	84	85.02	84.48	80.29	58.48	88.83	87.23	96.61	93.74	81.57	70.87	92.54	94.15	90.21	80.47
762	84	85.63	85.08	80.79	58.73	89.46	87.53	96.87	94.09	82.05	71.92	92.79	94.51	90.91	81.21
676	83	86.48	85.76	81.29	58.98	90.05	87.81	97.15	94.43	82.59	72.93	93.07	94.85	91.61	82.09
692	83	87.28	86.40	81.83	59.24	90.61	88.09	97.41	94.75	83.10	74.57	93.33	95.17	92.26	82.97
677	82	88.12	87.07	82.33	59.50	91.15	88.35	97.66	95.05	83.84	76.23	93.63	95.50	92.88	83.84
292	81	89.00	87.77	83.03	59.74	91.65	88.60	97.89	95.32	84.73	77.96	93.92	95.84	93.51	84.80
613	81	89.82	88.42	83.68	59.97	92.15	88.84	98.12	95.57	85.56	79.55	94.23	96.20	94.09	85.70
6771	79	90.61	89.08	84.32	60.18	92.61	89.07	98.36	95.81	86.86	81.04	94.60	96.55	94.63	86.53

Farm no.	Rel. Pro-duction	C	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo	R^2
694	78	91.34	89.67	84.92	60.40	93.02	89.29	98.57	96.03	88.04	82.48	94.93	96.88	95.12	87.29
755	78	92.11	90.23	85.53	61.21	94.04	89.66	98.79	96.40	89.13	83.96	95.23	97.24	95.64	88.26
273	77	93.05	90.76	86.19	62.29	95.27	89.99	98.98	96.83	90.28	86.69	95.60	97.63	96.14	89.53
311	77	93.98	91.22	87.52	63.30	96.34	90.40	99.15	97.21	91.67	89.08	95.93	98.04	96.63	91.05
756	76	94.82	91.67	88.77	64.32	97.28	90.78	99.33	97.63	92.88	91.23	96.21	98.43	97.06	92.42
769	73	95.56	92.13	90.04	66.04	98.07	91.10	99.48	98.00	94.00	93.07	96.82	98.76	97.43	93.57
767	70	97.29	92.50	91.32	67.41	98.77	91.63	99.61	98.34	94.89	94.74	97.38	99.06	97.94	95.78
241	69	98.63	94.12	93.78	68.51	99.29	94.77	99.73	98.95	97.02	97.33	98.69	99.37	98.85	97.87
754	69	99.54	96.33	96.33	71.23	99.69	97.81	99.85	99.39	98.86	99.10	99.56	99.70	99.55	99.27
788	67	100	100	100	100	100	100	100	100	100	100	100	100	100	100

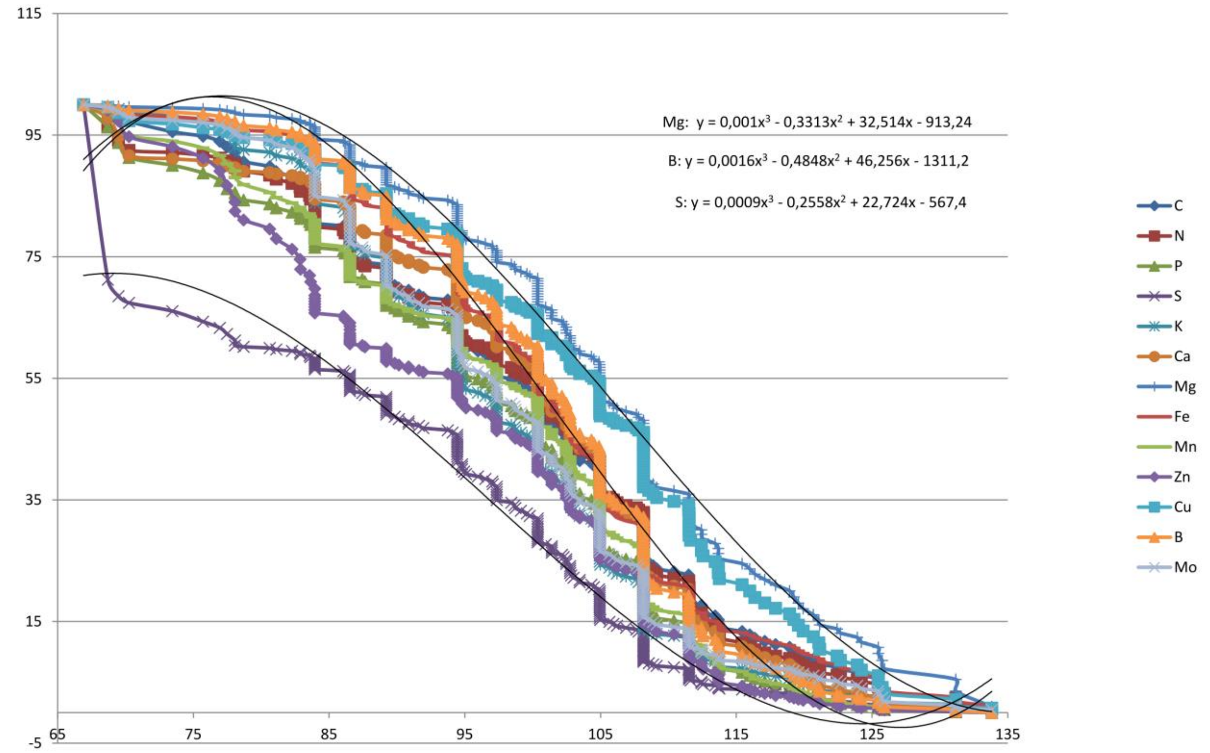
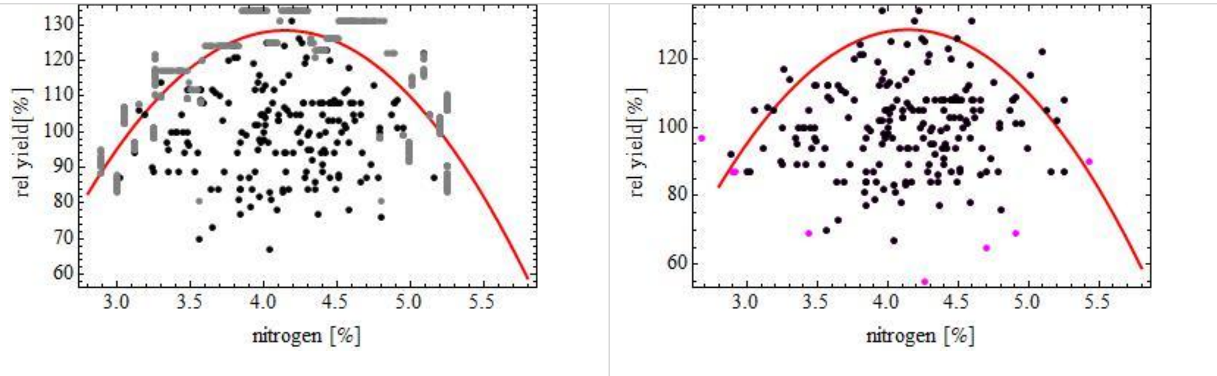
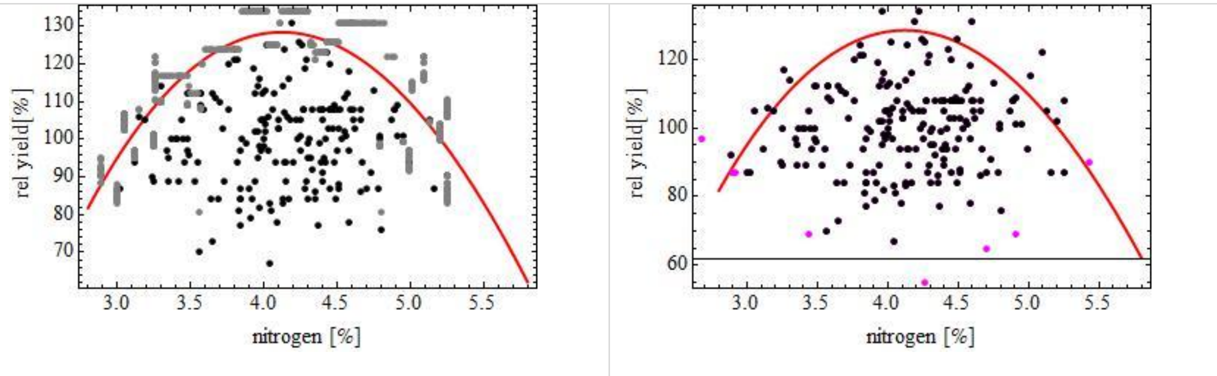


Fig. 8.4: Cumulative variance ratios and selected variance ratio fuctions of plant nutrients of organically grown Egyptian cotton (*Gossypium barbadense*) calculated according to Khiari et al., 2001a.

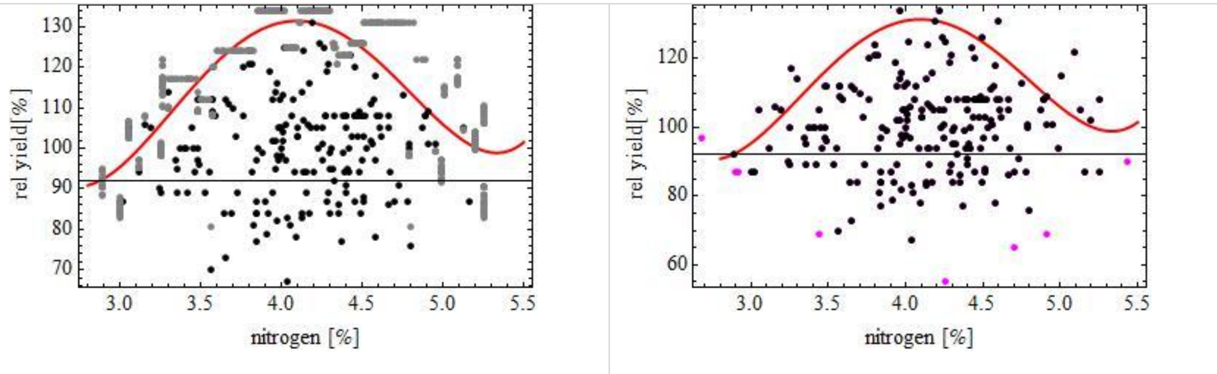
Fig. 8.5: Boundary lines as polynomials of 2nd, 3rd and 4th order fitted to the step function (gray points) and drawn in relation to the original scatter diagrams with outliers marked (magenta points).



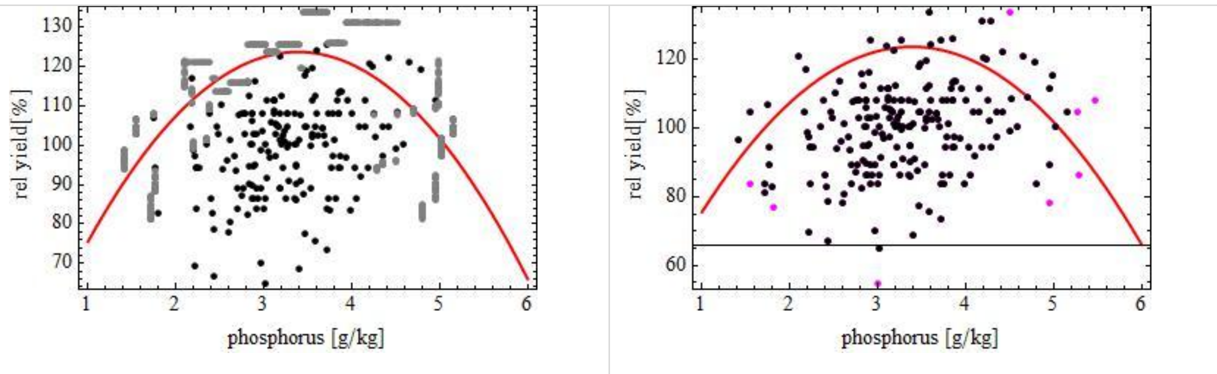
$y = -306.562 + 209.963\,x - 25.334\,x^2$; CV=4.14; $3.64<x<4.65$; $2.90<x<4.65$[1)]



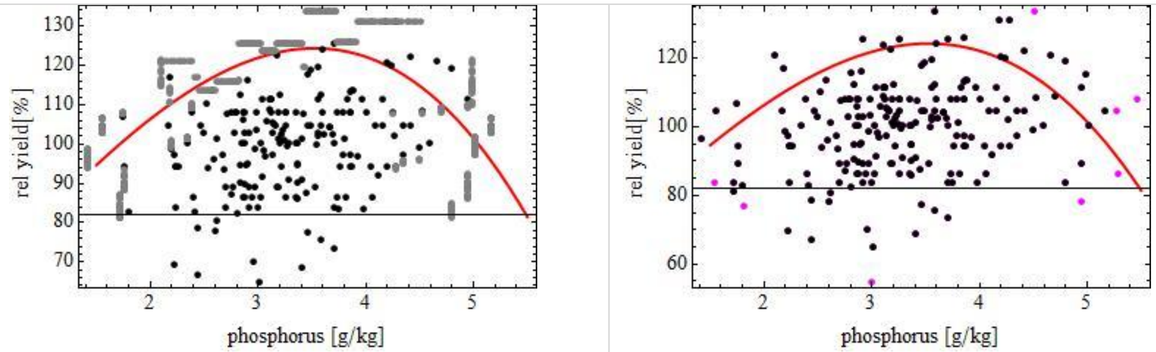
$y=-376.125+262.961x-38.492x^2+1.066x^3$; CV=4.12; $3.62<x<4.63$; $2.90<x<4.63$



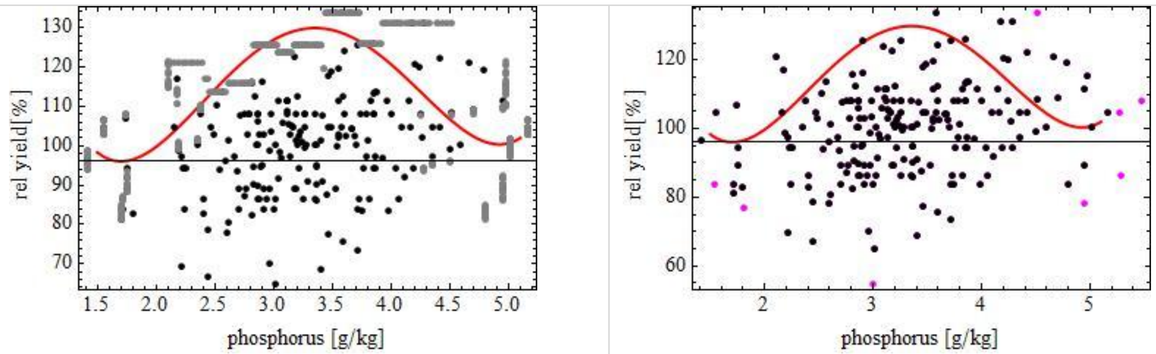
$y=2936.97-3129.59x+1245.34x^2-211.754x^3+13.045x^4$; CV=4,09; $3.70<x<4.50$; $2.90<x<4.50$



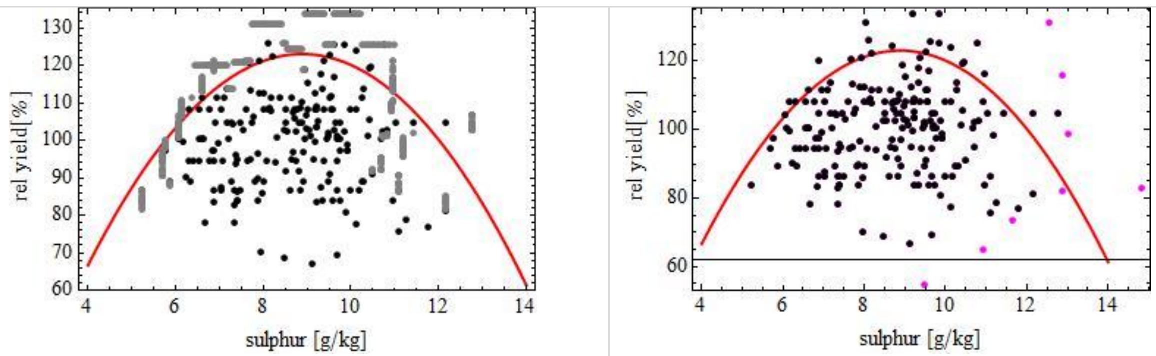
$y=26.763+57.231x-8.446x^2$; CV=3.39; $2.35<x<4.24$; $1.42<x<4.24$



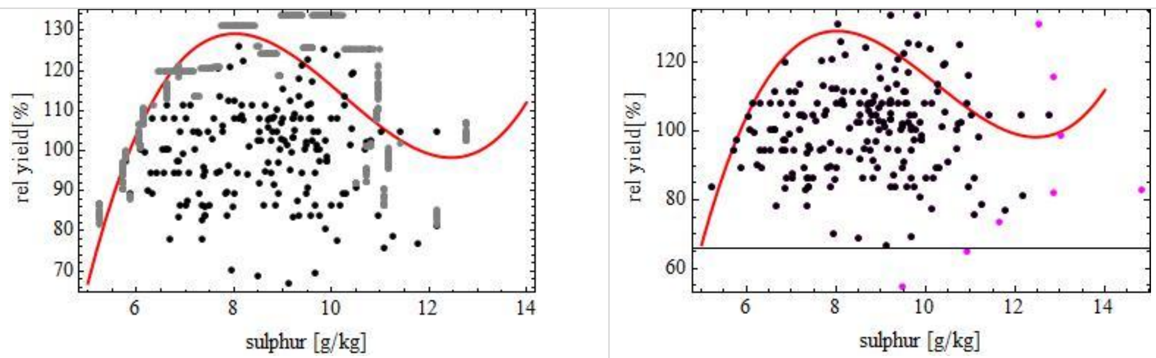
$y=52.263+29.077x+0.897x^2-0.949x^3$; CV=3.53; $2.66<x<4.32$; $1.42<x<4.32$



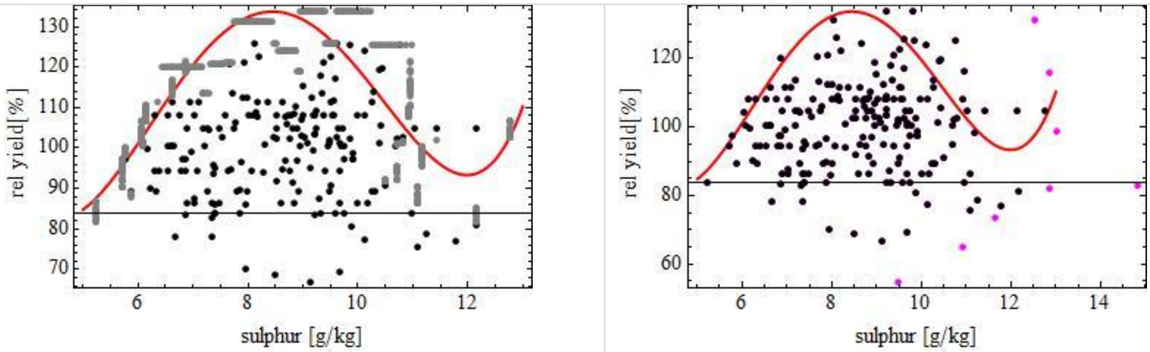
$y=430.537-527.78\,x+287.369x^2-62.479x^3+4.695x^4$; CV=3.35; $2.83<x<3.89$; $1.42<x<3.89$



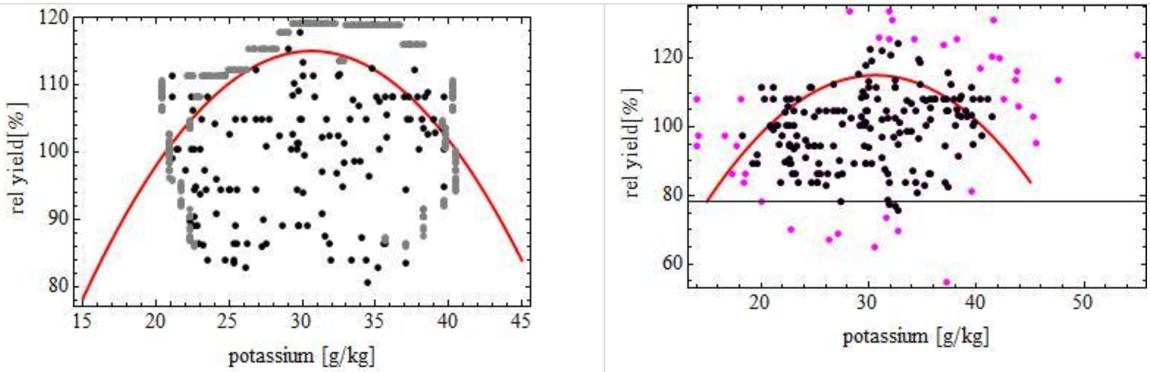
$y=-63.40+41.960x-2.361x^2$; CV=8.89; $7.27<x<10.50$; $5.23<x<10.50$



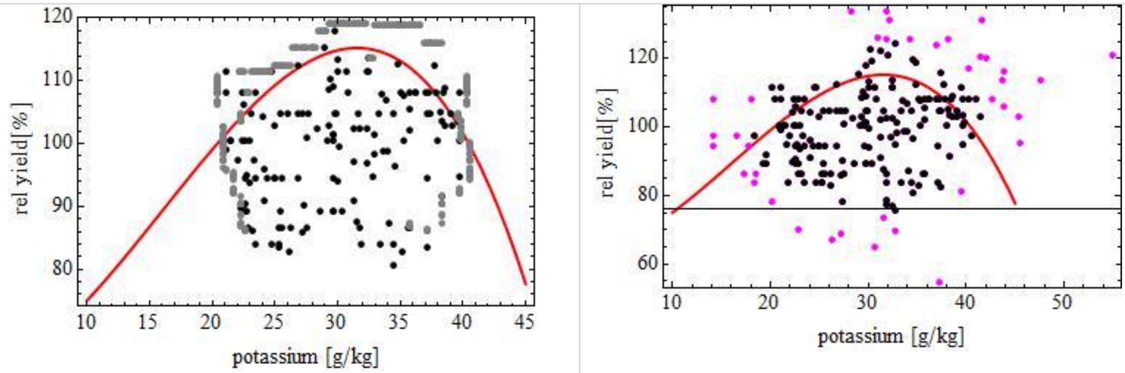
$y=-536.526+211.367x-21.6591^2+0.705x^3$; CV=8.02; $6.93<x<9.33$; $5.23<x<9.33$



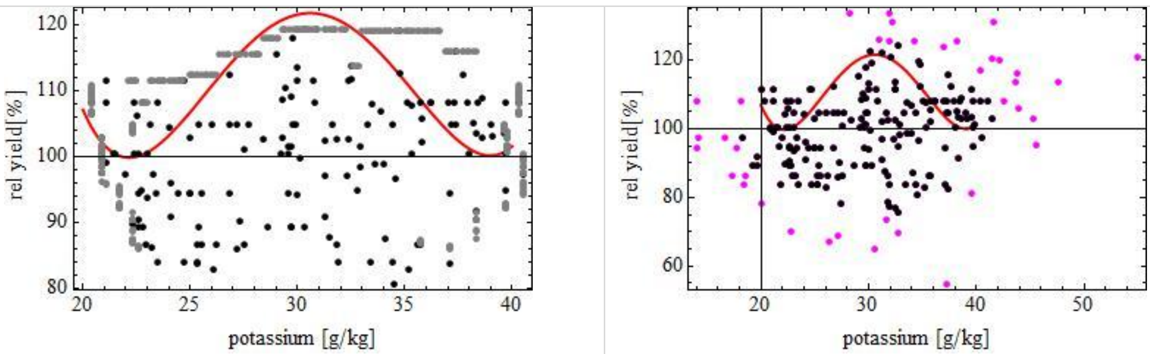
$y=832.093-450.165x+94.515x^2-8.086x^3+0.242x^4$; CV=8.45; 7.13<x<9.79; 5.23<x<9.79



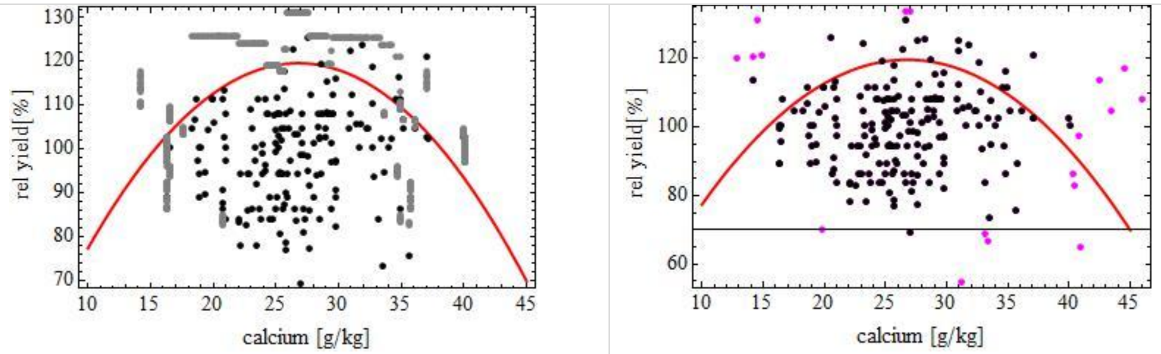
$y=-26.400+9.24x-0.151x^2$; CV=30.74; 21.43<x<40.04; 14.21<x<40.04



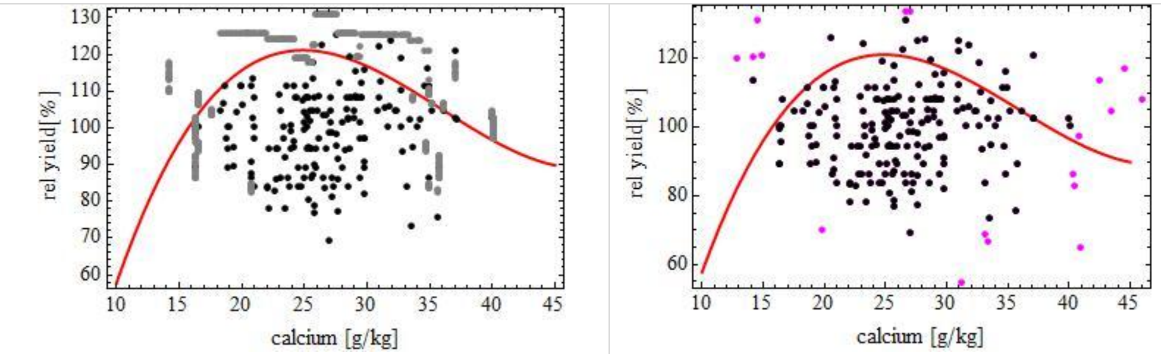
$y=63.3837-0.151x+0.166x^2-0.003x^3$; CV=32.55; 22.96<x<40.68; 14.21<x<40.68



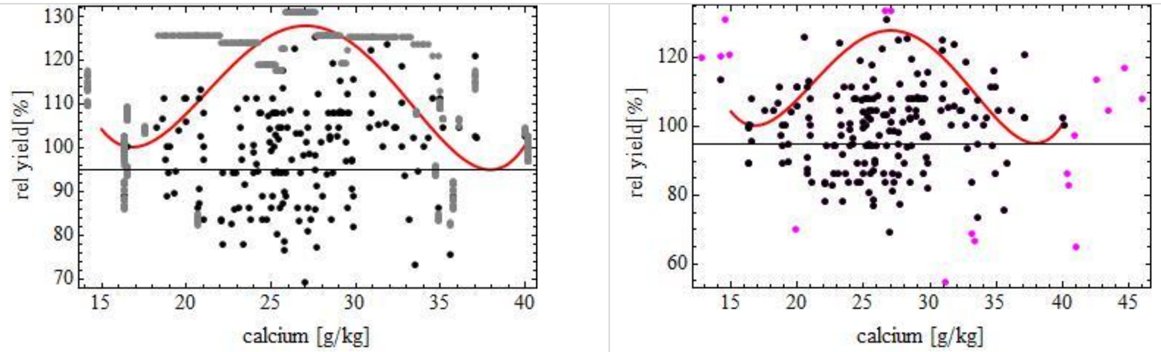
$y=3332.1-457.589x+23.678x^2-0.53x^3+0.004x^4$; CV=30.38; 25.71<x<35.16; 14.21<x<35.16



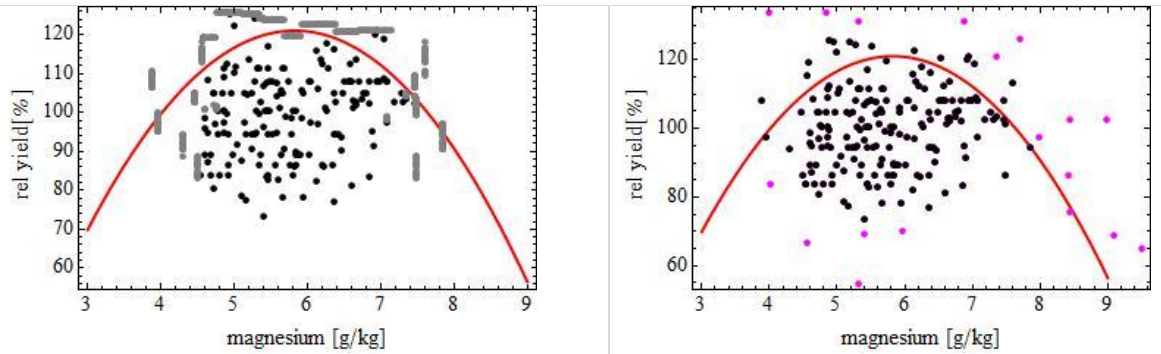
$y=12.123+8.029x-0.150x^2$; CV=26,78; 20.47<x<33.10; 16.30<x<33.10



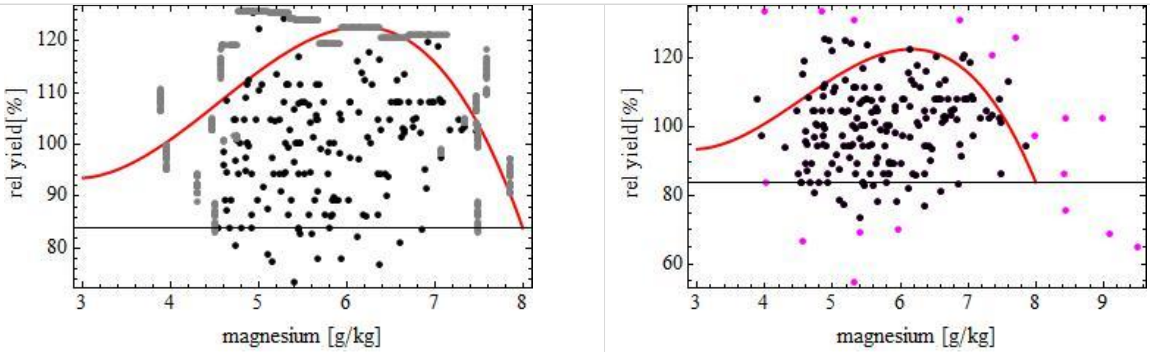
$y=-92.916+20.888x-0.6419x^2+0.006x^3$; CV=24.89; 19.74<x<31.04; 16.30<x<31.04



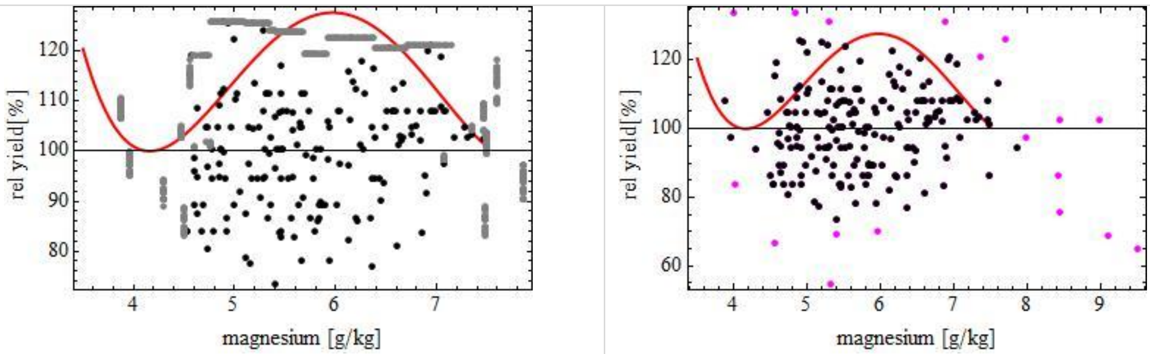
$y=1069.7-166.953x+10.256x^2-0.264x^3+0.002x^4$; CV=27.03; 23.46<x<30.55; 16.30<x<30.55



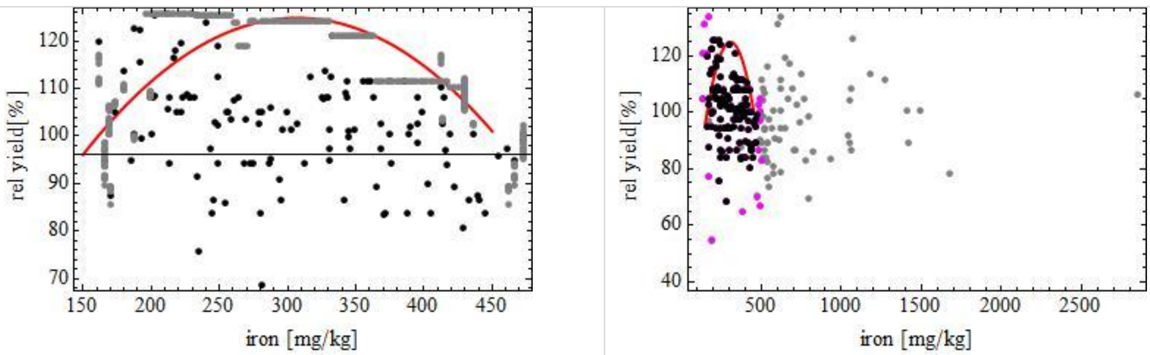
$y=-96.348+74.644x-6.407x^2$; CV=5.83; 4.85<x<6.80; 3.90<x<6.80



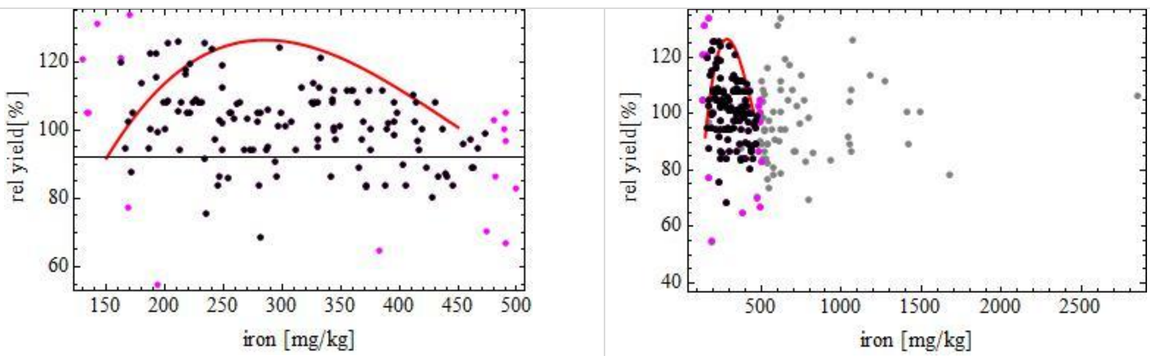
$y=207.819-92.901x+23.427x^2-1.719x^3$; CV=6.16; $5.21<x<6.96$; $3.90<x<6.96$



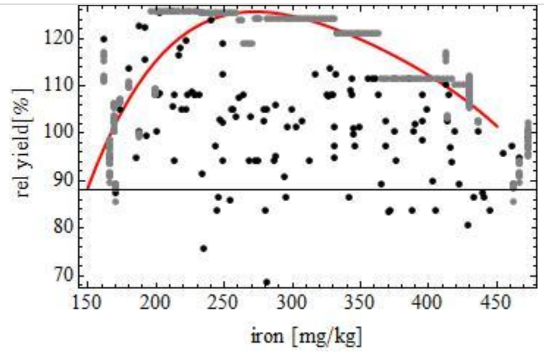
$y=2764.81-1963.71x+525.778x^2-60.4241x^3+2.522x^4$; CV=5.97; $5.36<x<6.60$; $3.90<x<6.60$

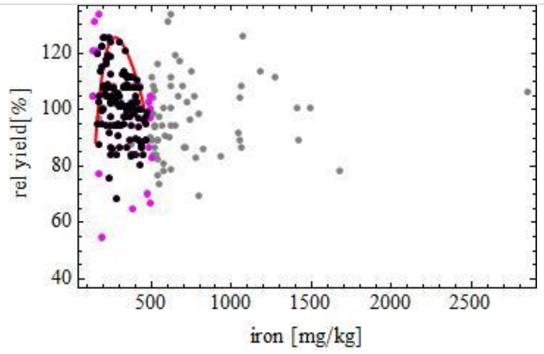


$y= 14.946 +0.716x-0.0012x^2$; CV=307.03; $233.86<x<380.21$; $166.20<x<380.21$

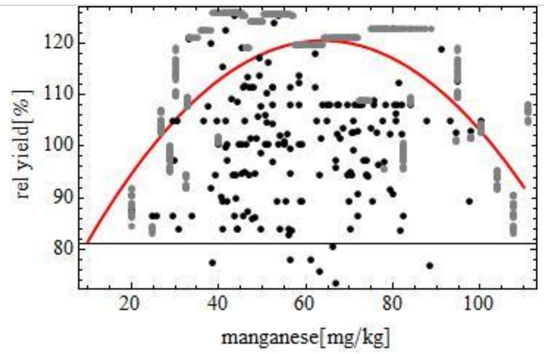


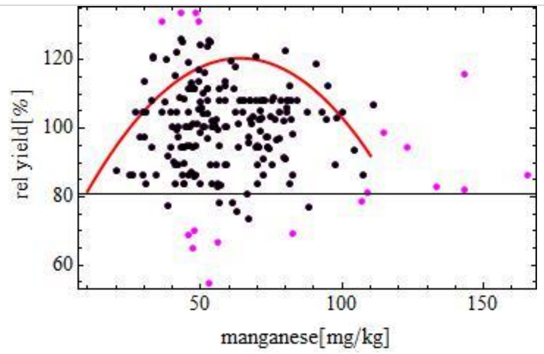
$y= -65.81+1.603x-0.004x^2+3.146*10^{-6}x^3$; CV=285.42; $223.64<x<365.91$; $166.20<x<365.91$



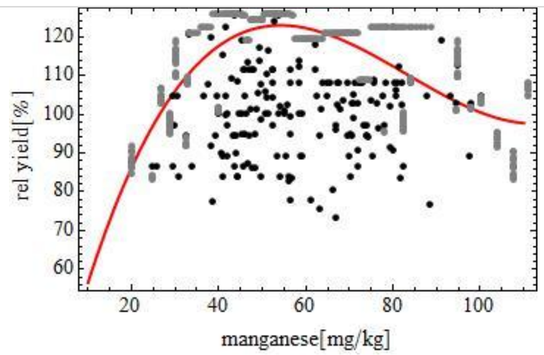


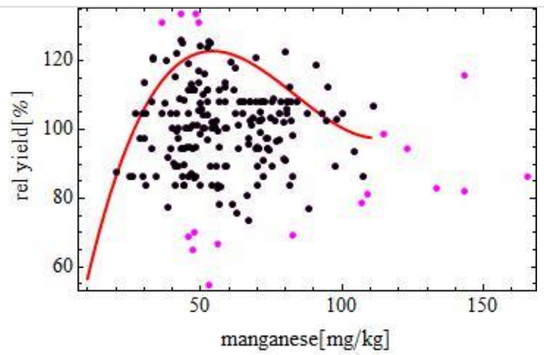
$y=-210.49+3.687x-0.015x^2+0.00003x^3-1.797*10^{-8}x^4$; CV=272.60; $213.00<x<353.56$; $166.20<x<353.56$



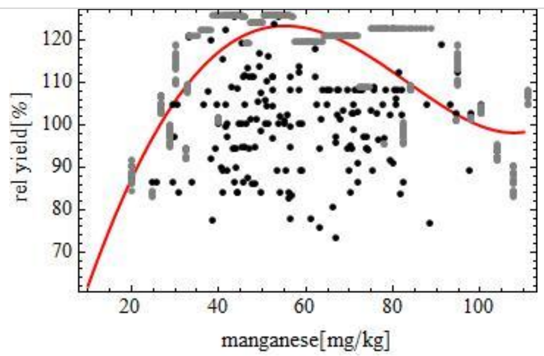


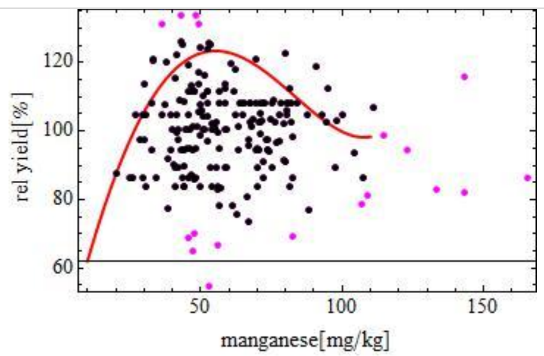
$y=65.811+1.711x-0.013x^2$; CV=63.91; $42.70<x<85.13$; $20.00<x<85.13$



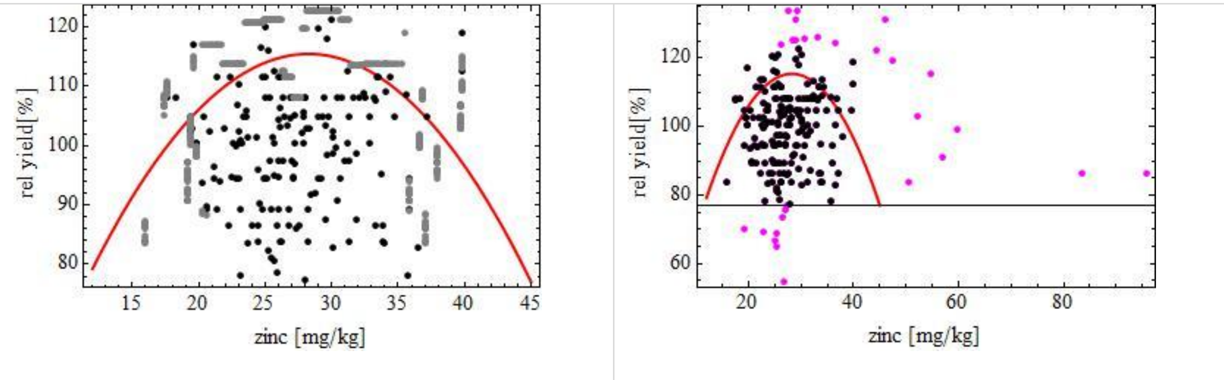


$y=15.606+4.719x-0.065x^2+0.0003x^3$; CV=54.20; $38.96<x<72.83$; $20.00<x<72.83$

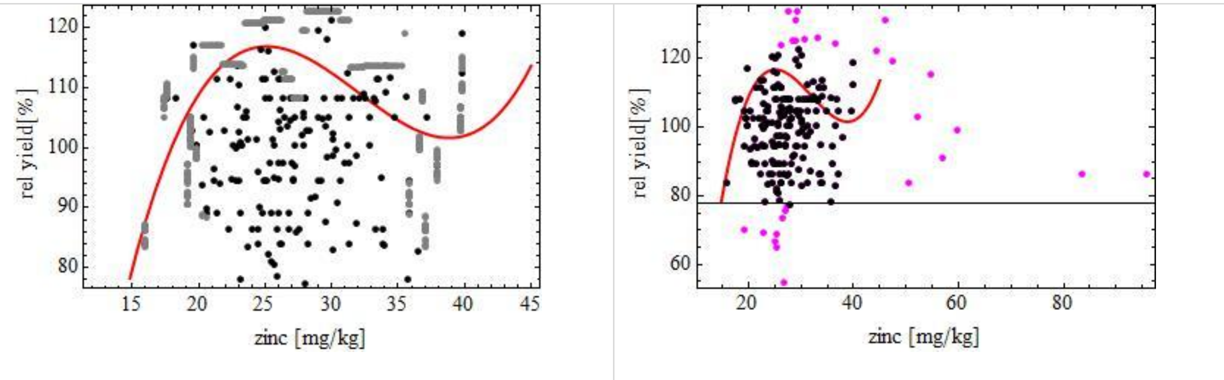




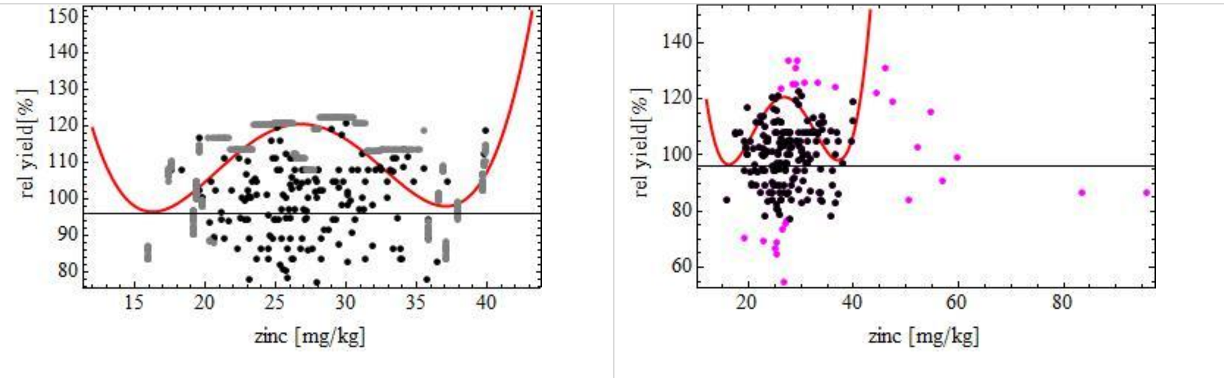
$y=29.919+3.542x-0.032x^2-0.0001x^3+1.376*10^{-6}x^4$; CV=55.22; $39.93<x<72.97$; $20.00<x<7297$



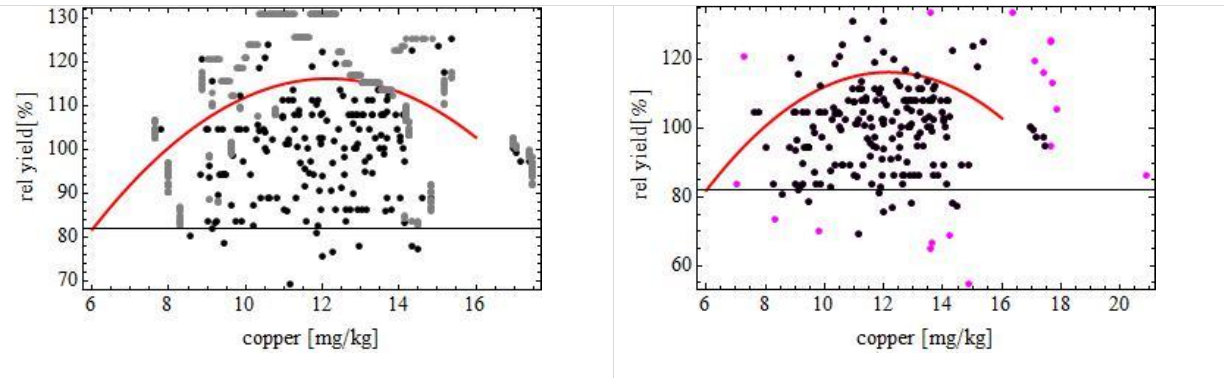
$y= 6.213+7.728x-0.137x^2$; CV=28.26; $21.76<x<34.75$; $16.00<x<34.75$



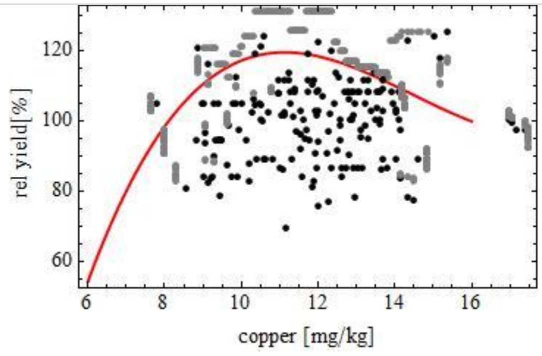
$y=-221.997+34.396x-1.128x^2+0.012x^3$; CV=25.11; $20.66<x<38.83$; $16.00<x<38.83$

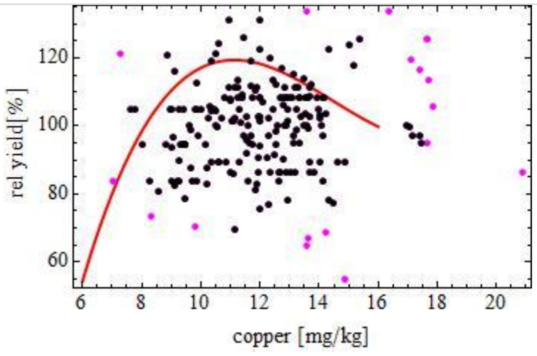


$y=822.04-128.209x+8.064x^2-0.212x^3+0.002x^4$; CV=26.80; $22.92<x<30.70$; $16.00<x<30.70$

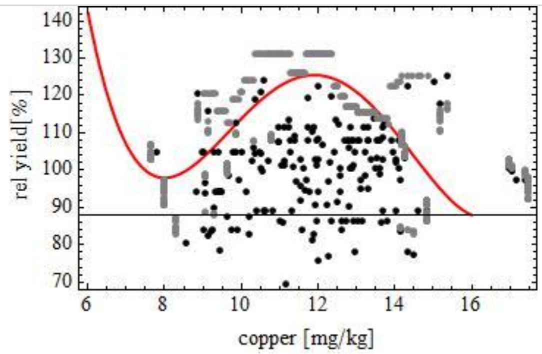


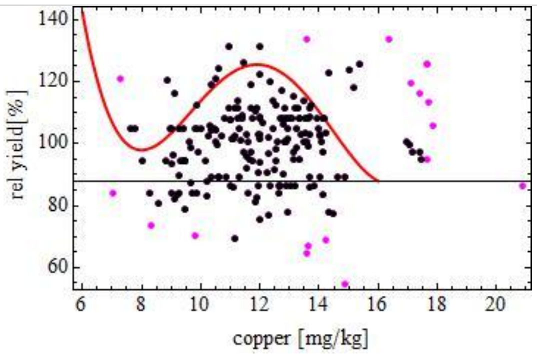
$Y=-17.926+22.097x-0.909x^2$; CV=12.16; $9.63<x<14.69$; $7.99<x<14.69$



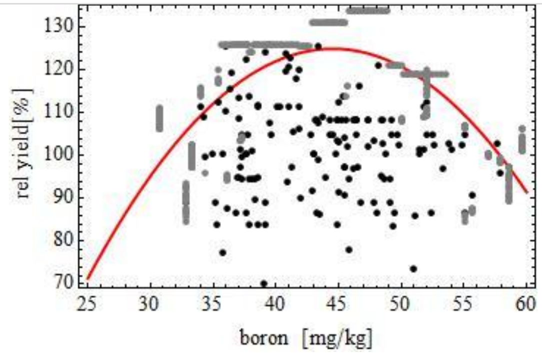


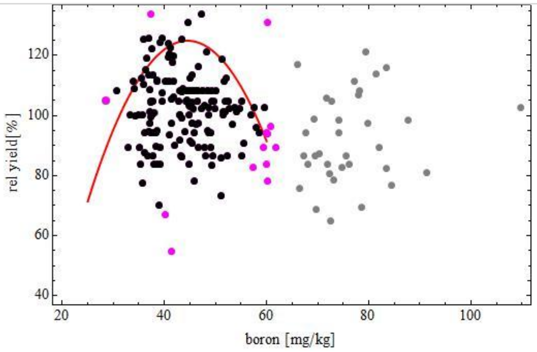
$y=-309.874+97.551x-7.133x^2+0.165x^3$; CV=11.13; $9.37<x<13.30$; $7.99<x<13.30$



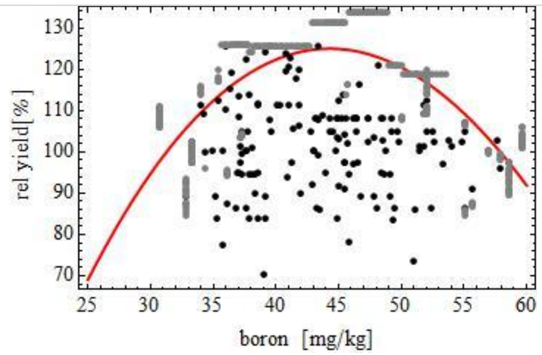


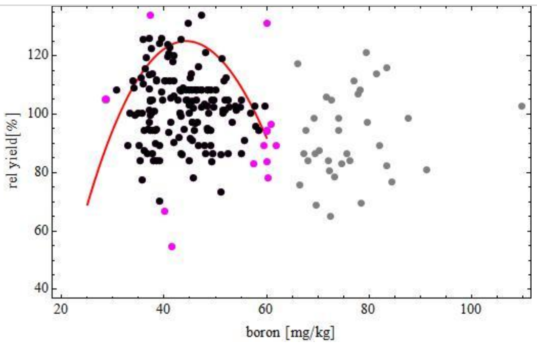
$y=1910.09-678.906x+91.776x^2-5.278x^3+0.109x^4$; CV=11.90; $10.55<x<13.21$; $7.99<x<13.21$



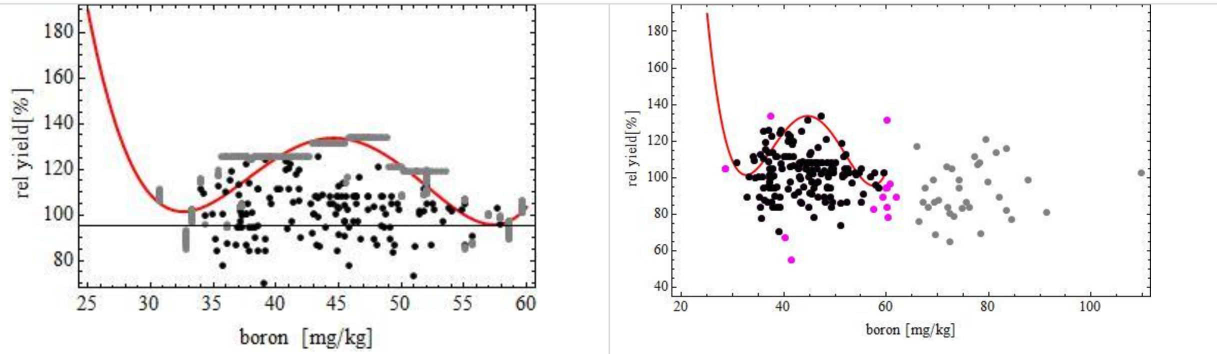


$y=-153.145+12.485x-0.140x^2$; CV=44.55; $37.87<x<51.22$; $33.00<x<51.22$

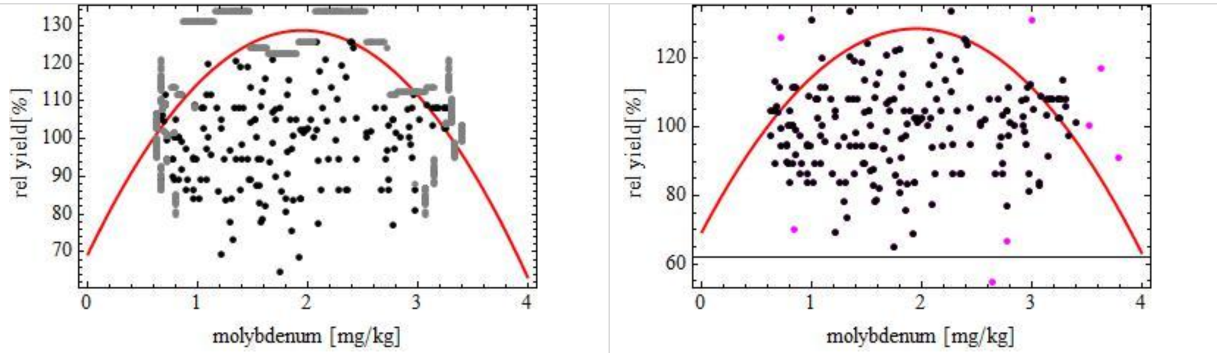




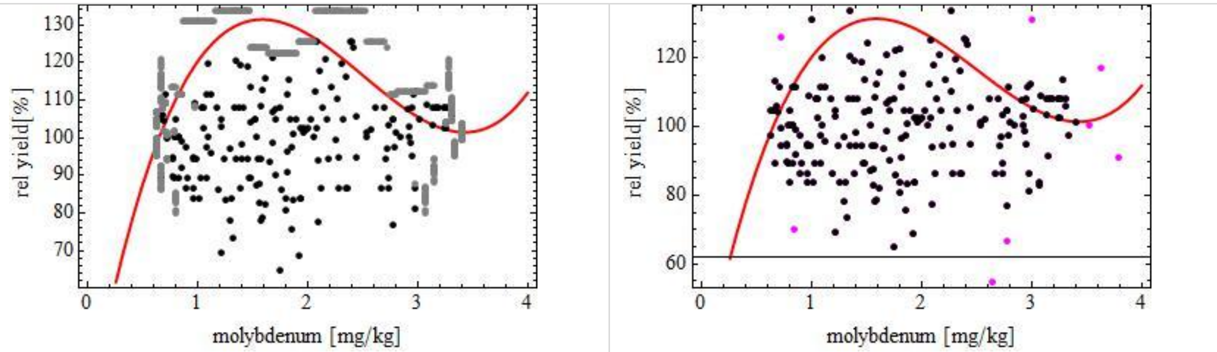
$y=-192.074+15.210x-0.202x^2+0.0005x^3$; CV=44.30; $37.72<x<51.02$; $33.00<x<51.02$



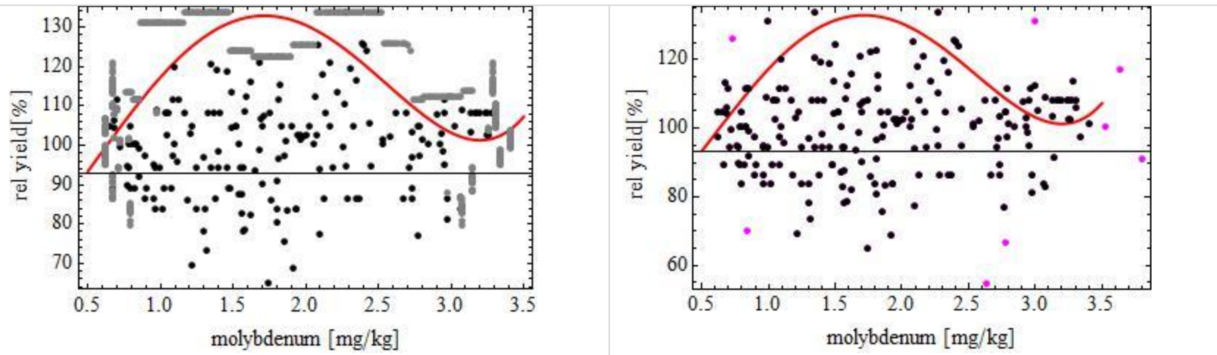
$y= 5245.98-495.931x+17.481x^2-0.266x^3+0.001x^4$; CV=44.63; $40.67<x<48.53$; $33<x<48.53$



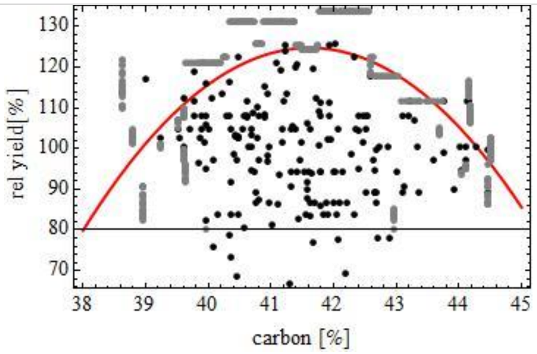
$y=69.437+60.766x-15.572x^2$; CV=1.95; $1.31<x<2.59$; $0.62<x<2.59$

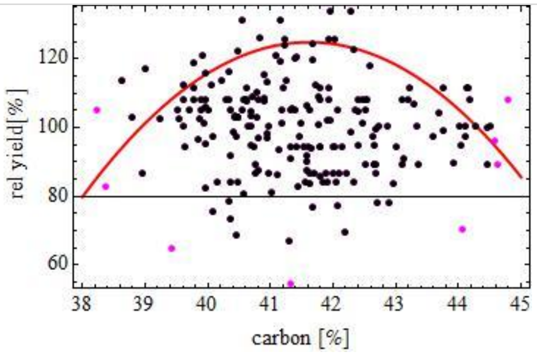


$y=26.276+156.81x-72.296^2+9.612x^3$; CV=1.59; $1.13<x<2.14$; $0.62<x<2.14$

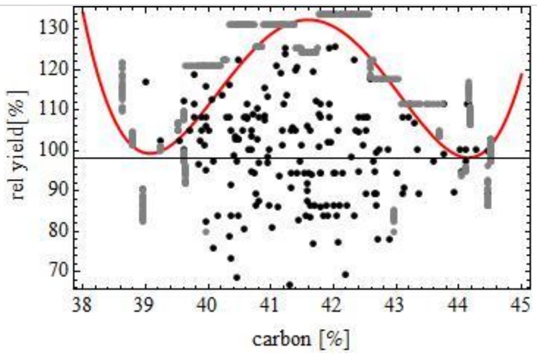


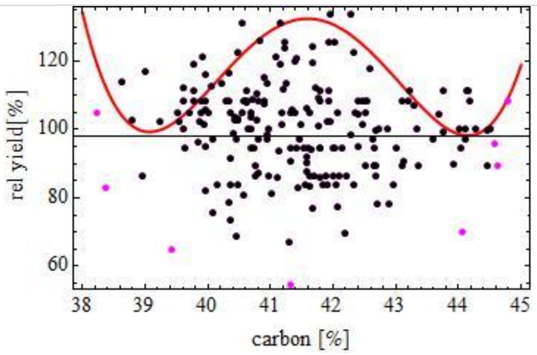
$Y=73.265+23.468x+49.541x^2-34.418x^3+5.469x^4$; CV=1.71; $1.25<x<2.20$; $0.62<x<2.20$



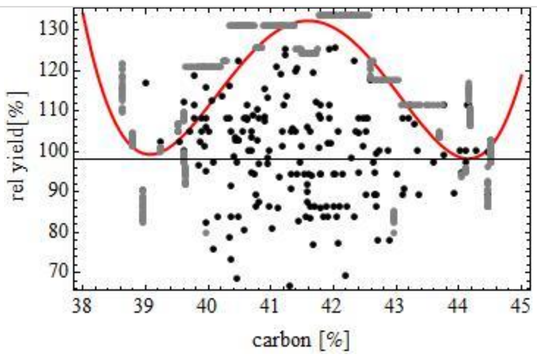


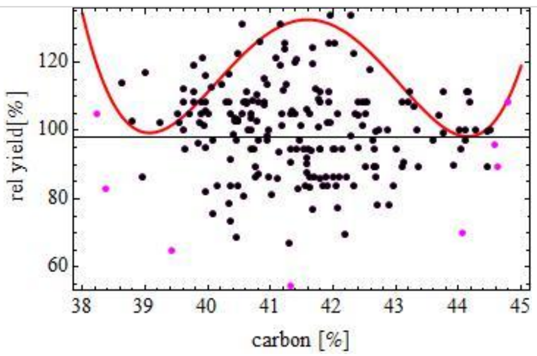
$y=-5820.45+285.697x-3.432x^2$; CV=41.62; 40.27<x<42.98; 38.95<x<42.98





$y=12953.4-1071.86x+29.249x^2-0.262x^3$; CV=41.86; 40.48<x<43.12; 38.95>x<43.12

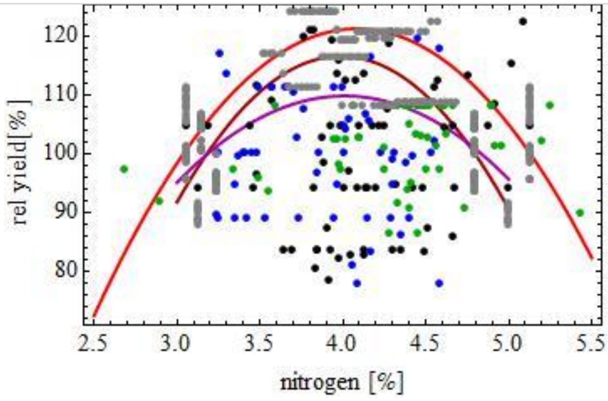




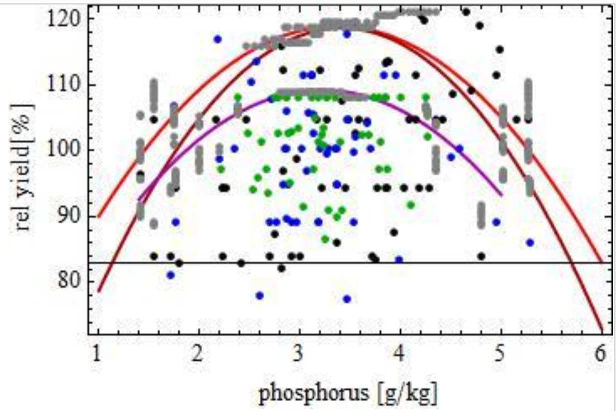
$Y=2.40392*10^6-231969x+8383.99x^2-134.508x^3+0.808x^4$; CV=41.60; 40.78<x<42.41; 38.95<x<42.41

[1)]Equation of polynomial; critical value; critical range; validity range

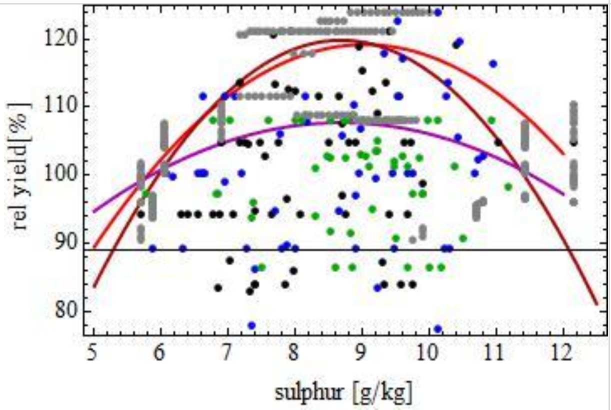
Fig. 8.6: Variation according to the year of sampling: Scatter diagrams and boundary lines with respect to element concentration in plant tissue samples of *Gossypium barbadense*[1)].



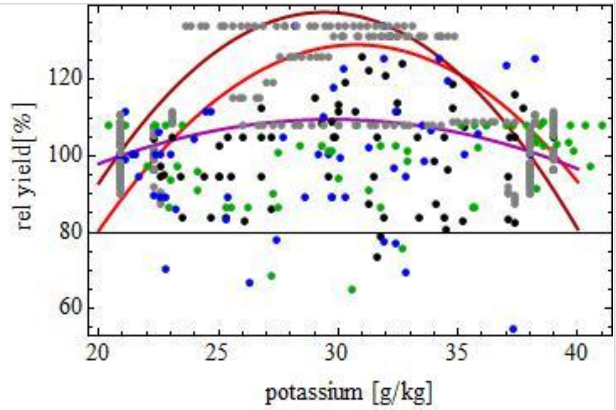
CV_{2008}=4.08; CV_{2009}= 3.99; CV_{2010}=4.01



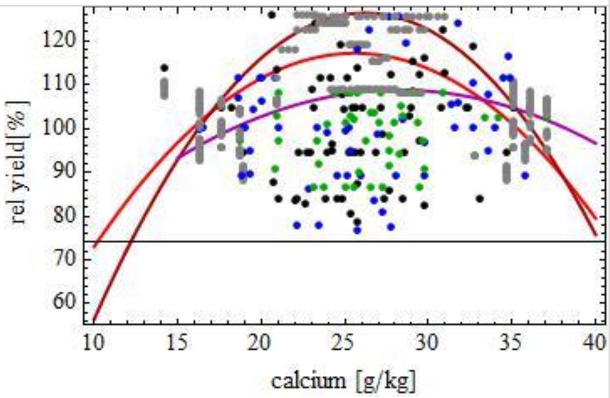
CV_{2008}=3.36; CV_{2009}=3.42; CV_{2010}=3.22



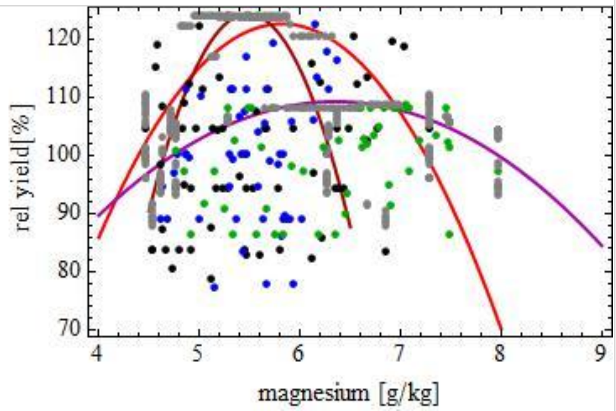
CV_{2008}=9.04; CV_{2009}=8.69; CV_{2010}=8.69



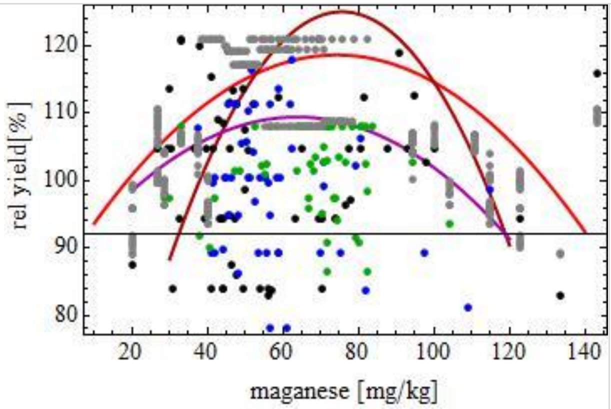
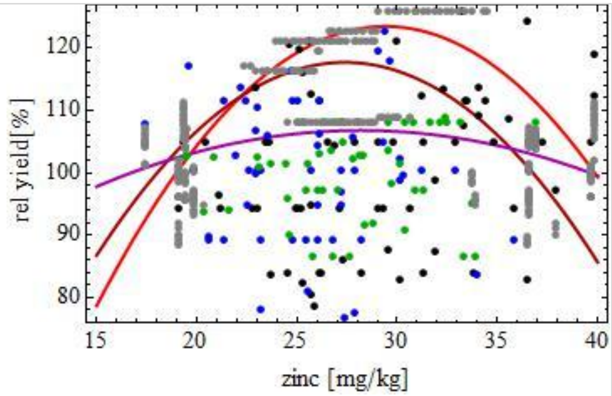
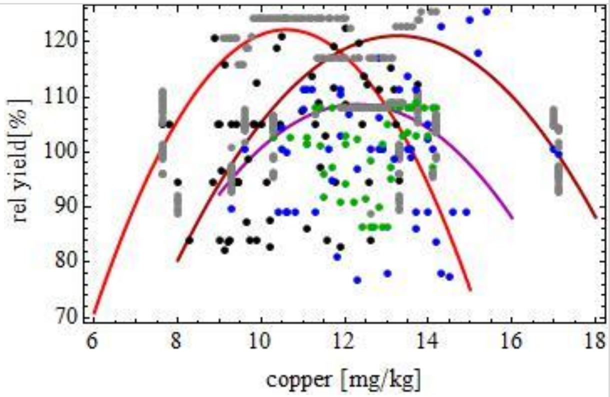
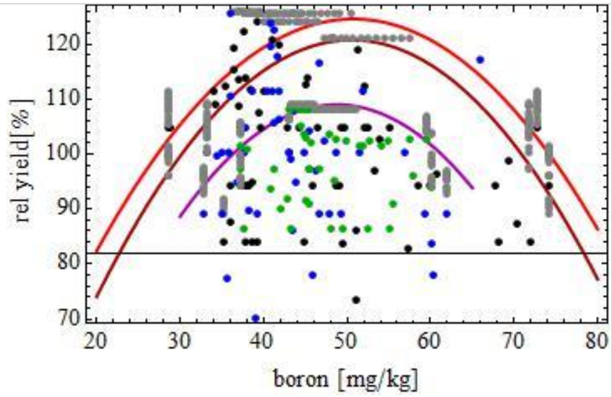
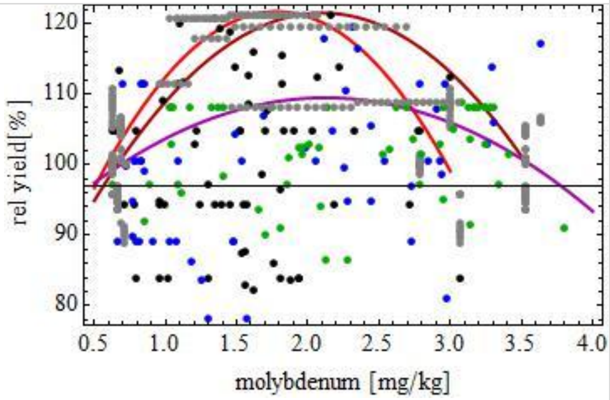
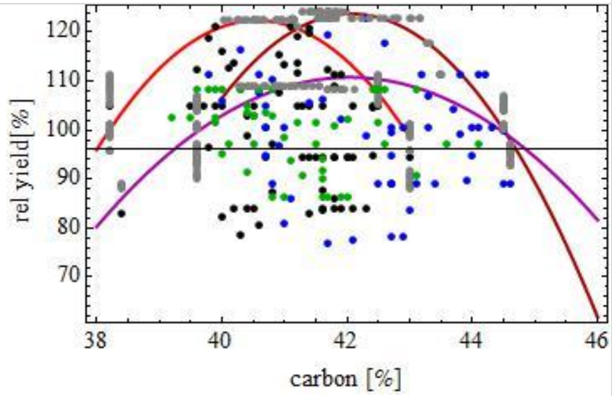
CV_{2008}=30.76; CV_{2009}=29.40; CV_{2010}=29.73



CV_{2008}=25.60; CV_{2009}=26.21; CV_{2010}=28.27

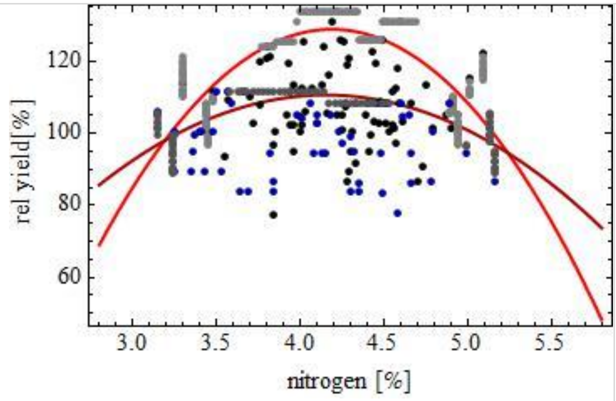


CV_{2008}=5.82; CV_{2009}=5.48; CV_{2010}=6.35

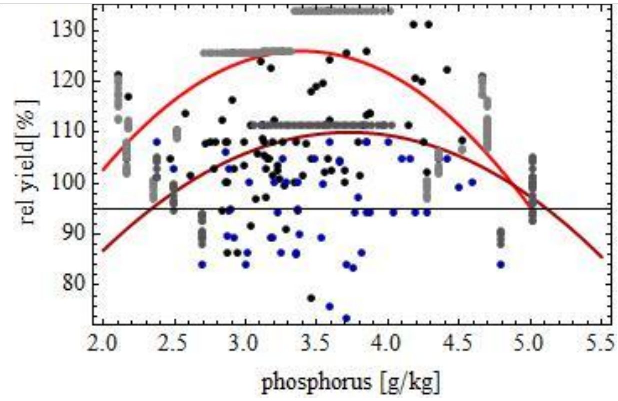
	
CV_{2008}=74.21; CV_{2009}=75.65; CV_{2010}=63.75	CV_{2008}=29.41; CV_{2009}=27.39; CV_{2010}=28.17
	
CV_{2008}=10.60; CV_{2009}=13.27; CV_{2010}=12.29	CV_{2008}=50.74; CV_{2009}=50.53; CV_{2010}=48.79
	
CV_{2008}=1.78; CV_{2009}=2.10; CV_{2010}=2.12	CV_{2008}=40.56; CV_{2009}=42.07; CV_{2010}=42.05

[1)] 2008=black points, red line, 2009=blue points, dark red line, 2010=green points, lilac line

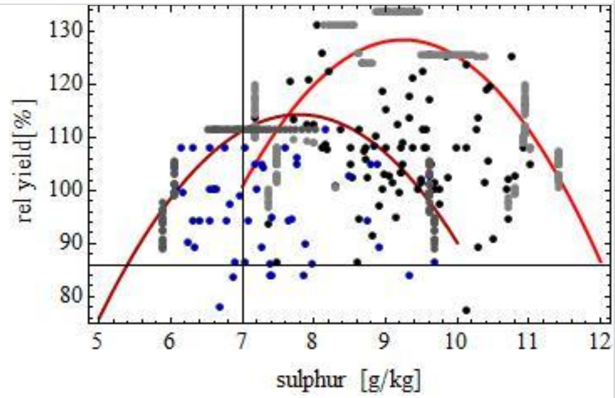
Fig. 8.7: Variation between two sampling regions: Scatter diagrams and boundary lines with respect to element concentration in plant tissue samples of Gossypium barbadense.



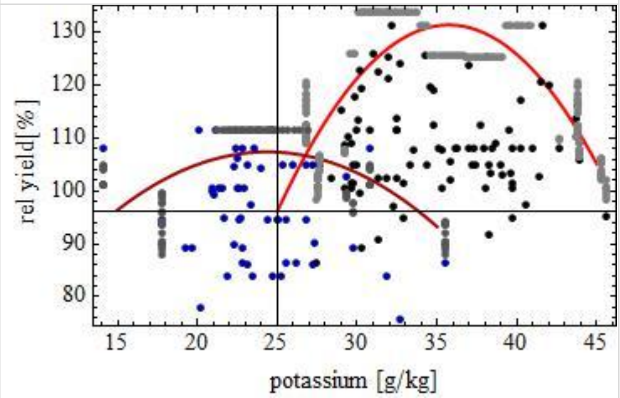
$CV_{Beheira}$=4.19; $CV_{Sharqia}$=4.15;



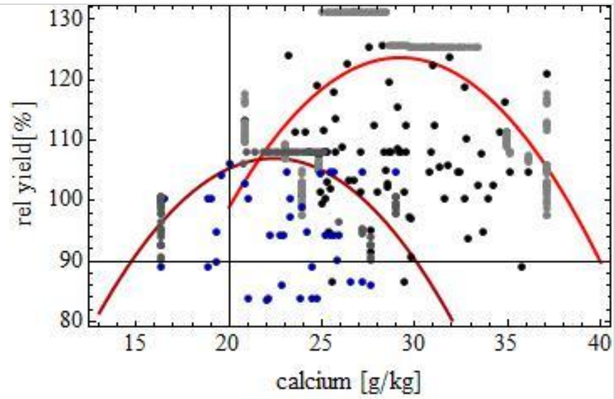
$CV_{Beheira}$=3.40; $CV_{Sharqia}$=3.73;



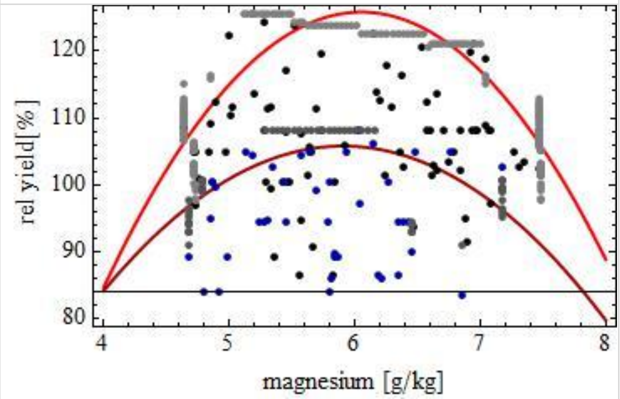
$CV_{Beheira}$=9.24; $CV_{Sharqia}$=7.79;



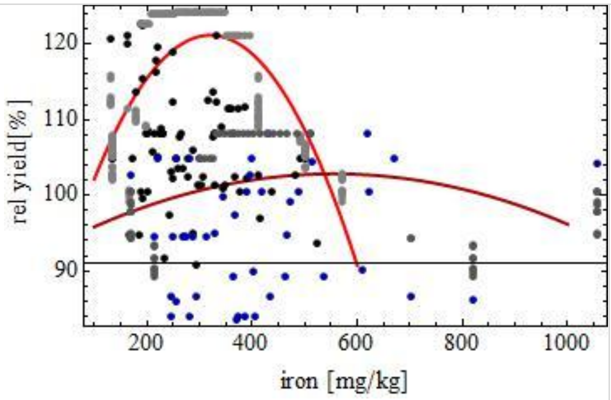
$CV_{Beheira}$=35.73; $CV_{Sharqia}$=24.37;



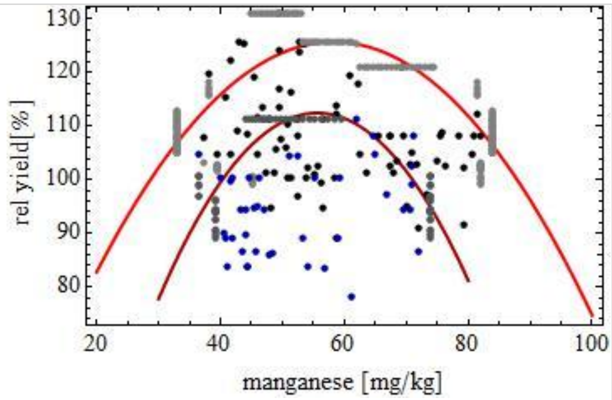
$CV_{Beheira}$=29.21; $CV_{Sharqia}$=22.40;



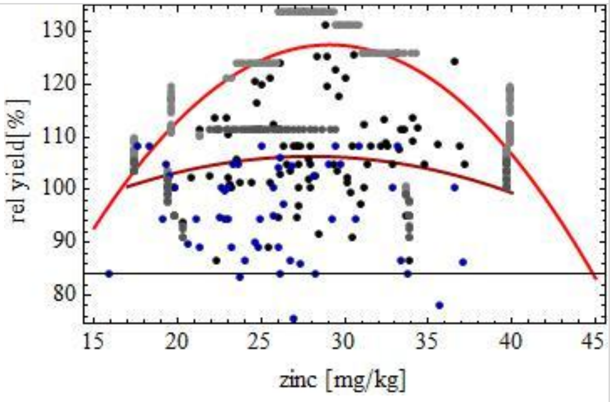
$CV_{Beheira}$=6.05; $CV_{Sharqia}$=5.91;



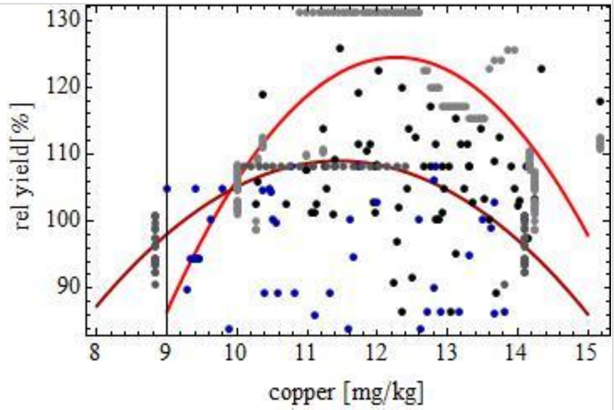
$CV_{Beheira}$=320.72; $CV_{Sharqia}$=555.55;



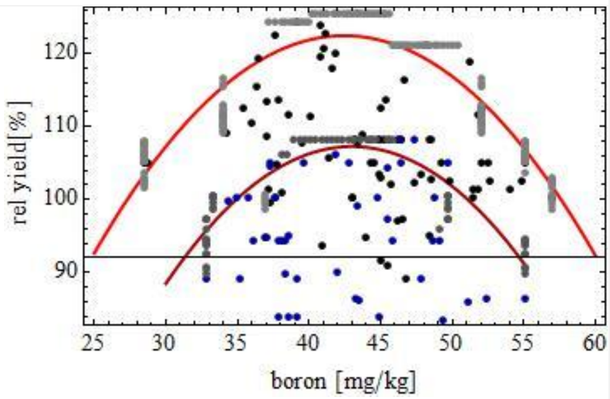
$CV_{Beheira}$=58.28; $CV_{Sharqia}$=55.64;



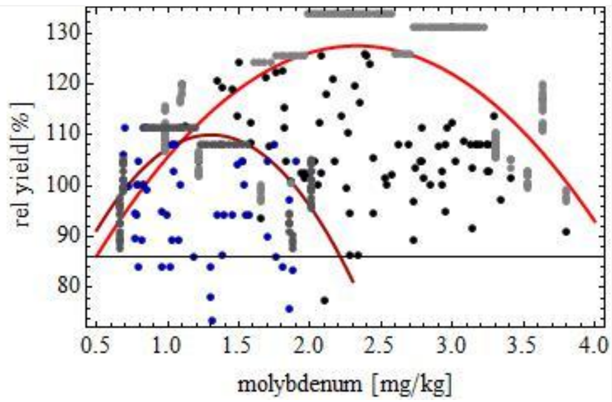
$CV_{Beheira}$=29.09; $CV_{Sharqia}$=27.97;



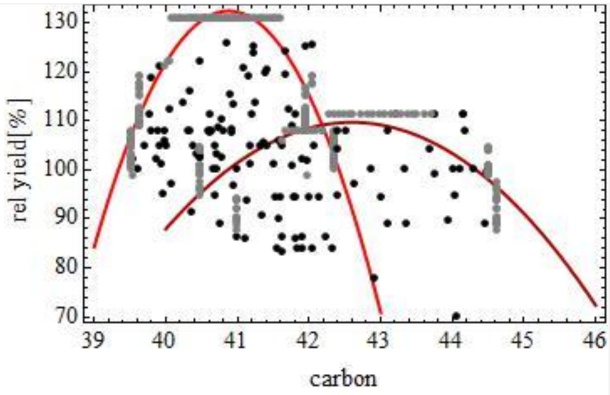
$CV_{Beheira}$=12.27; $CV_{Sharqia}$=11.45;



$CV_{Beheira}$=42.45; $CV_{Sharqia}$=42.99;



$CV_{Beheira}$=2.32; $CV_{Sharqia}$=1.30;



$CV_{Beheira}$=40.68; $CV_{Sharqia}$=42.60;

[1)]Beheira governorate=black points, red line, Sharqia governorate=blue points, dark red line;

Tab. 8.23: Deficiency-indices according to PIPPA-evaluation for 207 samples of organically grown Egyptian cotton (*Gossypium barbadense*) sampled between 2008 and 2010.

Farm no.	Year*)	Region	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo	Al
2	1	Qalyubia	0.4	18.1	8.3	35.9	-	-	-	-	-	-	-	-	-
36	1	Qalyubia	1.5	-	4.0	4.2	-	-	-	-	-	-	-	3.3	-
36	2	Qalyubia	0.7	-	-	0.9	0.1	17.8	-	0.4	-	-	-	1.3	-
152	1	Beheira-W	1.0	10.3	-	-	-	0.1	-	1.5	-	2.4	-	-	-
163	1	Beheira-W	-	-	-	0.5	-	8.4	7.8	2.0	-	-	7.4	-	13.9
163	2	Beheira-W	0.3	-	-	-	-	4.2	-	0.1	-	-	8.1	-	6.5
163	3	Beheira-W	-	-	-	-	0.4	1.6	-	9.5	-	-	-	-	6.2
205	1	Faiyum	-	9.0	-	-	-	4.4	-	-	-	1.3	-	-	-
205	2	Faiyum	-	9.7	-	-	-	-	-	-	-	-	-	-	-
205	3	Faiyum	-	4.9	1.2	0.2	-	12.4	-	-	1.0	-	-	-	-
241	1	Faiyum	1.4	1.2	-	-	-	7.9	-	-	-	3.1	-	-	-
241	2	Faiyum	9.7	9.4	-	-	-	0.9	-	-	-	-	-	3.1	-
241	3	Faiyum	8.4	4.3	4.9	5.7	13.2	7.9	-	-	-	-	-	5.3	-
256	1	Beheira-W	-	5.7	-	-	-	6.4	14.6	3.1	-	-	-	-	17.1
258	1	Qalyubia	9.1	8.8	-	7.0	0.1	0.5	-	0.2	-	-	-	20.3	-
266	1	Beheira-W	-	-	1.1	-	1.0	0.1	-	-	-	-	2.0	-	-
266	2	Beheira-W	-	-	-	-	-	5.1	15.8	-	-	-	5.6	-	16.0
266	3	Beheira-W	0.8	-	-	0.8	-	-	-	-	7.4	-	-	-	-
266	3	Beheira-W	0.3	-	0.6	-	-	-	-	-	-	0.9	-	-	-
266	3	Beheira-W	0.7	0.2	0.8	-	-	-	-	-	3.0	-	-	-	-
273	2	Beheira-W	1.9	-	-	-	-	2.4	16.1	3.9	-	-	8.6	-	15.7
273	3	Beheira-W	-	4.1	-	-	-	-	-	-	-	-	-	-	-
273	3	Beheira-W	-	-	-	0.3	-	-	-	-	-	-	-	-	-
273	3	Beheira-W	-	-	-	0.2	-	-	-	-	-	-	-	-	-
292	1	Faiyum	1.8	23.3	-	19.5	-	0.7	-	-	-	14.2	-	-	-
292	2	Faiyum	0.2	19.2	-	-	-	-	-	-	-	-	-	-	-
292	3	Faiyum	-	9.3	-	26.0	-	-	-	-	-	-	-	-	-
308	1	Beheira-W	-	0.2	-	2.0	-	4.6	-	-	-	-	9.1	-	6.5
308	2	Beheira-W	-	0.6	-	-	-	0.5	-	-	-	-	1.4	-	7.6
308	3	Beheira-W	-	-	-	-	-	-	-	-	-	-	-	-	-
311	1	Faiyum	0.4	23.0	-	-	0.1	1.8	-	-	4.0	5.5	-	-	-
311	2	Faiyum	-	17.1	-	-	0.2	-	-	-	-	-	-	-	-
318	1	Faiyum	1.0	9.1	-	-	-	8.9	-	-	-	5.5	-	-	-
318	2	Faiyum	3.3	18.1	-	0.2	0.4	0.2	-	-	3.5	0.2	-	0.2	-
444	1	Faiyum	1.2	2.8	-	-	0.2	7.6	-	-	-	3.3	-	0.1	-
457	1	Faiyum	8.8	26.6	2.5	-	0.9	1.0	-	-	2.1	7.0	-	-	-
488	1	Faiyum	-	1.5	-	-	-	7.1	-	-	-	2.9	-	-	-

Farm no.	Year*)	Region	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo	Al
488	2	Faiyum	-	18.5	-	-	8.5	0.9	-	-	-	-	-	-	-
488	3	Faiyum	-	-	-	5.6	4.6	1.8	-	-	-	-	-	-	-
541	1	Beheira-O	-	-	1.5	-	-	3.7	7.8	1.5	-	-	5.3	-	13.1
541	2	Beheira-O	-	1.6	-	-	-	-	0.6	-	-	-	-	-	10.3
613	1	Faiyum	1.9	4.1	-	-	0.3	6.4	-	-	-	11.3	-	-	-
666	1	Faiyum	20.6	9.2	1.8	0.2	1.1	5.9	-	-	-	17.6	-	9.6	-
676	1	Faiyum	-	6.5	-	-	-	0.3	-	-	-	1.1	-	-	-
677	1	Faiyum	0.6	2.3	-	-	-	-	-	-	-	6.5	-	-	-
677	1	Faiyum	0.6	2.3	-	-	-	-	-	-	-	6.5	-	-	-
677	3	Faiyum	-	1.7	-	-	1.3	-	-	-	-	-	-	-	-
679	1	Dakahl.-Da	-	-	19.9	-	7.8	2.3	-	1-	-	4.5	5.7	2.7	-
679	2	Dakahl.-Da	-	-	-	3.6	-	7.8	-	-	-	-	-	11.6	-
679	3	Dakahl.-Da	42.1	-	-	9.9	0.1	2.5	-	15.0	-	2.0	-	12.3	-
680	1	Dakahl.-Da	-	-	7.1	-	4.6	2.7	15.6	29.5	-	1.1	7.8	-	12.4
680	2	Dakahl.-Da	-	-	-	3.8	0.1	0.8	-	-	-	-	-	2.6	-
680	3	Dakahl.-Da	30.9	-	0.8	15.9	1.5	3.2	-	4.2	-	-	0.1	13.8	-
682	2	Beheira-W	-	0.5	-	-	-	0.2	2.0	-	-	-	1.0	-	10.2
682	3	Beheira-W	7.0	3.3	5.0	7.7	-	-	-	-	4.4	7.1	1.3	-	-
683	1	Beheira-W	9.7	-	-	-	-	5.2	-	-	-	-	-	3.1	-
683	3	Beheira-W	-	0.1	-	-	-	0.1	-	-	-	-	-	-	6.4
685	1	Beheira-W	2.0	11.3	-	-	-	-	-	-	-	27.9	-	-	-
685	2	Beheira-W	-	1.6	-	-	-	2.2	4.6	-	-	-	-	-	12.3
685	3	Beheira-W	-	-	-	-	0.3	-	-	-	-	-	-	-	-
686	1	Beheira-W	-	0.3	0.8	-	-	-	-	-	-	1.7	-	-	7.0
686	2	Beheira-W	-	0.3	-	0.2	0.1	-	9.1	-	-	-	1.1	-	11.5
688	1	Beheira-W	-	-	0.6	-	0.5	0.3	-	-	-	-	2.7	-	6.2
688	2	Beheira-W	-	0.1	-	-	-	4.6	2.2	-	-	-	2.7	-	1-
688	3	Beheira-W	-	0.2	1.2	1.4	1.1	6.1	-	-	-	-	4.6	-	-
689	1	Beheira-W	-	-	-	-	-	-	-	-	-	-	-	-	6.2
689	3	Beheira-W	-	0.3	-	-	0.5	0.2	-	-	-	-	5.9	-	-
690	1	Beheira-W	-	-	-	-	-	-	-	-	-	0.6	-	0.4	11.7
690	2	Beheira-W	-	0.1	-	0.2	0.5	1.3	7.4	-	-	-	5.8	-	12.2
692	1	Qalyubia	0.2	17.1	5.2	2.8	2.2	0.7	-	-	-	-	-	-	-
692	2	Qalyubia	-	2.6	2.1	0.6	0.2	-	-	-	-	-	-	0.3	-
692	3	Qalyubia	-	0.1	-	12.0	-	-	-	-	-	-	-	1.5	-
692	3	Qalyubia	-	2.4	0.6	13.8	-	0.5	-	-	-	-	-	0.7	-
692	3	Qalyubia	-	-	2.0	20.7	0.3	0.6	-	-	-	-	-	4.1	-
694	2	Qalyubia	0.1	4.2	5.1	1.5	1.5	0.1	-	-	-	-	-	-	-
696	2	Qalyubia	0.8	1.2	2.8	8.5	-	-	-	-	-	-	-	16.7	-
696	3	Qalyubia	12.9	3.5	19.1	35.6	8.2	5.0	-	13.3	-	-	5.9	25.3	-
696	3	Qalyubia	0.5	-	8.4	19.9	4.2	18.5	-	1.4	-	-	1.0	6.0	-
710	1	Beheira-O	-	-	6.1	-	19.9	-	12.0	13.1	-	-	-	-	10.1
710	2	Beheira-O	1.8	0.7	-	-	-	6.3	-	-	-	-	-	-	-
710	3	Beheira-O	-	0.4	-	-	-	-	-	-	-	-	-	-	8.7
712	3	Beheira-W	-	-	0.8	-	0.4	-	-	-	-	-	-	-	-
721	2	Beheira-O	0.3	0.6	0.6	-	-	-	-	-	-	0.8	-	-	6.7
721	3	Beheira-O	-	1.1	-	-	-	-	-	-	-	-	-	-	8.8
724	1	Beheira-O	23.4	-	4.4	0.2	9.2	9.8	33.1	17.6	-	22.6	28.1	23.7	2-
724	2	Beheira-O	9.5	7.4	-	-	-	1.5	-	-	5.9	-	-	-	-
724	3	Beheira-O	-	1.7	-	-	-	-	-	-	-	-	-	-	6.5
725	1	Beheira-O	2.4	-	2.3	-	17.8	-	18.8	9.2	-	0.4	-	-	11.2
725	2	Beheira-O	15.5	1-	-	-	-	0.7	-	-	6.4	-	-	-	-
725	3	Beheira-O	-	2.5	-	-	-	-	-	-	-	-	-	-	-
726	2	Beheira-O	0.4	-	-	-	-	0.9	-	-	-	-	-	-	-
726	3	Beheira-O	-	2.4	-	-	-	-	-	-	-	-	-	-	8.5
727	1	Beheira-O	-	-	1.7	-	4.9	-	-	0.6	-	-	6.2	19.7	-
727	3	Beheira-O	-	0.8	0.6	-	-	-	-	-	-	-	-	-	8.2
728	1	Beheira-O	0.9	-	-	0.1	0.6	8.3	-	-	-	-	7.2	0.9	-
728	2	Beheira-O	2.8	3.1	1.5	-	-	0.8	-	4.9	15.8	-	-	-	6.9
728	3	Beheira-O	-	1.8	-	-	-	-	-	-	-	-	-	-	8.4
729	1	Beheira-O	-	-	3.2	0.2	4.5	-	-	-	-	-	6.2	22.6	-
729	2	Beheira-O	3.9	5.2	0.6	0.3	-	3.5	-	-	-	-	8.1	-	-
729	3	Beheira-O	-	0.3	-	-	-	-	1.5	-	-	-	-	-	11.6

Farm no.	Year*)	Region	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo	Al
732	1	Beheira-O	-	-	1.9	-	18.7	-	28.8	5.7	-	-	-	8.5	18.6
732	2	Beheira-O	0.5	0.5	-	-	-	1.3	-	-	-	-	-	-	-
732	3	Beheira-O	-	1.9	-	-	-	-	-	-	-	-	-	-	8.2
733	1	Beheira-O	6.6	-	-	0.2	1.9	5.0	-	0.7	-	-	11.9	9.1	-
734	1	Beheira-O	-	-	0.6	0.4	-	7.5	4.7	-	-	-	6.1	-	10.8
734	2	Beheira-O	-	1.9	-	-	-	0.7	9.4	-	-	-	0.1	-	12.3
735	1	Beheira-O	17.9	-	8.2	0.2	10.6	3.9	32.5	13.6	-	20.3	28.8	25.2	19.6
735	2	Beheira-O	-	-	0.7	-	0.3	7.6	17.3	-	-	-	6.4	-	15.9
736	1	Beheira-O	0.1	2.0	2.1	-	-	-	-	-	-	-	-	-	6.2
736	2	Beheira-O	-	-	-	0.4	0.4	-	5.2	-	-	-	5.3	-	10.5
736	3	Beheira-O	-	1.9	4.3	3.9	0.3	0.4	-	21.0	-	-	-	-	-
736	3	Beheira-O	-	1.4	0.7	1.4	-	-	-	8.3	-	-	-	-	-
737	2	Beheira-W	-	-	-	0.2	0.2	-	0.6	-	-	-	0.8	-	7.3
739	1	Beheira-W	2.4	-	0.6	-	1.6	1.6	-	-	-	0.2	3.1	0.2	6.3
739	2	Beheira-W	-	-	-	-	-	0.1	-	-	-	-	1.4	-	7.5
740	1	Beheira-W	0.4	-	2.4	-	-	-	-	-	-	2.3	-	-	6.2
740	2	Beheira-W	0.7	2.1	-	-	-	0.3	9.9	-	-	-	-	-	12.4
741	1	Beheira-W	4.5	-	0.7	0.2	1.4	1.4	-	-	-	-	12.4	6.0	-
741	2	Beheira-W	-	1.0	-	-	-	1.4	7.2	-	-	-	0.9	-	11.8
743	1	Beheira-O	-	-	3.4	-	19.8	-	35.3	9.3	-	8.4	1.2	1.3	20.5
743	3	Beheira-O	-	0.5	1.6	-	0.1	-	-	-	-	-	-	-	8.8
744	2	Beheira-O	-	-	-	-	-	-	-	-	-	-	-	-	6.4
745	1	Beheira-W	8.8	-	-	-	0.4	3.4	-	-	-	-	3.9	5.1	-
753	1	Sharqia-W	-	-	2.2	1.7	-	-	-	-	-	-	-	-	6.5
753	2	Sharqia-W	6.5	0.5	10.4	5.0	8.3	4.9	-	-	-	-	3.9	14.0	-
753	3	Sharqia-W	-	0.9	7.2	3.5	-	-	-	0.3	-	-	-	0.9	-
754	1	Sharqia-W	-	0.2	13.3	8.5	0.3	-	1.6	3.3	-	8.8	-	17.1	6.4
754	2	Sharqia-W	8.6	0.2	15.6	8.8	13.7	4.9	-	1.2	5.9	3.4	14.2	14.9	-
754	3	Sharqia-W	-	-	0.9	1.6	-	-	-	-	-	-	-	-	-
755	1	Sharqia-W	-	3.2	2.5	4.7	0.7	-	-	12.1	-	7.3	3.1	1.8	-
755	2	Sharqia-W	-	-	9.9	14.5	2.8	-	-	-	-	-	-	1.9	-
755	3	Sharqia-W	-	1.0	-	0.1	-	-	-	-	-	-	-	-	-
756	1	Sharqia-W	-	-	0.6	3.5	0.2	-	-	0.4	-	4.7	-	0.8	6.7
756	2	Sharqia-W	-	-	10.4	11.3	4.2	-	-	-	-	-	-	5.9	-
756	3	Sharqia-W	-	-	-	-	-	-	-	-	-	-	-	-	-
757	1	Sharqia-W	-	-	5.6	2.9	-	-	0.1	12.6	-	2.6	-	-	6.2
757	2	Sharqia-W	-	-	4.8	7.4	2.1	-	-	-	-	-	-	3.8	-
757	3	Sharqia-W	-	-	14.0	1.5	0.2	-	-	2.4	-	-	0.5	-	-
758	2	Sharqia-W	-	-	10.2	12.4	1.6	-	-	-	-	-	-	0.1	-
758	3	Sharqia-W	-	-	-	8.0	-	-	-	-	-	-	-	-	6.4
759	1	Sharqia-O	-	0.1	6.1	7.5	1.7	2.5	-	-	-	7.6	2.5	16.2	-
759	2	Sharqia-O	10.2	3.3	5.5	8.0	8.0	-	-	-	1.6	0.6	3.1	6.2	-
759	3	Sharqia-O	6.1	7.0	7.2	-	-	-	-	-	11.6	-	-	7.4	-
760	1	Sharqia-O	-	-	4.8	6.8	0.6	8.9	-	-	-	2.2	4.8	9.7	-
760	2	Sharqia-O	7.5	1.5	-	0.2	0.7	-	-	-	-	-	-	7.6	-
760	3	Sharqia-O	-	5.5	0.9	-	-	-	-	-	6.7	-	-	-	-
760	3	Sharqia-O	-	1.8	-	0.4	4.4	1.2	16.2	-	-	-	-	7.1	12.1
761	1	Sharqia-O	-	-	4.7	8.3	0.9	5.0	-	-	-	-	3.8	9.9	-
761	2	Sharqia-O	6.4	-	7.7	11.9	5.9	0.7	-	-	-	-	1.2	21.0	-
761	3	Sharqia-O	0.1	-	9.2	8.1	0.4	-	-	-	-	-	-	1.0	-
762	1	Sharqia-O	-	-	8.4	-	2.9	-	-	-	-	5.9	-	-	-
762	2	Sharqia-O	-	-	7.6	12.1	1.1	0.1	-	-	-	-	-	13.8	-
762	3	Sharqia-O	-	-	14.8	-	4.2	-	-	-	14.8	-	-	6.8	-
763	1	Sharqia-O	-	-	5.4	9.2	0.5	2.2	-	-	-	0.6	5.7	21.8	-
763	2	Sharqia-O	0.4	-	15.9	5.9	6.6	0.3	-	-	-	0.4	-	0.2	-
764	1	Sharqia-O	0.5	-	0.6	3.7	0.2	0.2	-	-	-	7.4	0.2	0.1	-
764	2	Sharqia-O	4.8	-	6.6	14.6	4.5	1.4	-	-	-	-	1.8	15.0	-
764	3	Sharqia-O	-	-	8.7	7.0	1.6	-	-	-	-	-	-	-	-
765	1	Sharqia-O	-	-	6.8	21.6	0.2	-	-	-	-	4.4	4.6	8.8	-
766	2	Sharqia-O	16.1	1.8	2.5	9.1	7.0	-	-	-	3.3	5.4	4.2	17.5	-
767	2	Sharqia-O	6.8	1.3	2.2	8.1	6.1	-	-	-	7.4	2.6	3.2	14.6	-
768	1	Sharqia-O	1.9	18.9	26.1	10.2	4.2	17.2	-	-	24.6	32.8	3.8	-	-
768	2	Sharqia-O	19.5	1.9	2.9	8.7	5.8	-	-	-	-	-	0.6	21.9	-

Farm no.	Year*)	Region	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo	Al
769	1	Sharqia-O	4.8	-	-	-	-	1.0	-	-	-	13.7	-	1.7	-
769	2	Sharqia-O	10.9	0.9	6.0	10.9	7.9	0.8	-	-	-	-	10.2	14.8	-
770	1	Sharqia-O	-	-	11.0	4.2	1.9	0.7	-	-	8.2	4.3	4.9	-	-
770	2	Sharqia-O	12.3	1.7	3.2	10.6	7.0	1.5	-	-	-	-	6.3	17.6	-
770	3	Sharqia-O	-	-	13.2	35.7	13.2	20.2	-	-	-	-	21.2	-	-
771	1	Sharqia-O	-	-	3.0	1.6	0.3	-	-	-	7.5	4.6	5.7	0.1	-
771	2	Sharqia-O	10.7	-	10.6	7.8	7.5	5.8	-	-	-	-	5.3	17.0	-
772	1	Sharqia-O	2.0	-	3.5	5.2	2.1	1.9	-	-	-	4.7	7.9	1.3	-
772	2	Sharqia-O	8.3	0.5	1.6	4.7	5.9	0.2	-	-	-	-	0.6	14.4	-
772	3	Sharqia-O	-	-	11.0	9.0	0.8	-	-	-	-	-	-	7.2	-
773	1	Sharqia-O	0.1	-	9.0	4.2	2.7	1.6	-	-	2.0	5.1	4.2	0.4	-
773	3	Sharqia-O	-	-	3.7	6.7	0.8	-	-	-	-	-	-	-	-
774	1	Sharqia-W	5.1	1.0	4.8	3.9	2.8	4.3	-	2.0	-	-	-	16.2	-
774	2	Sharqia-W	12.5	-	17.8	15.9	13.8	6.9	-	2.1	-	-	9.8	15.2	-
775	1	Sharqia-W	-	-	12.4	2.1	0.4	-	-	-	-	4.3	-	-	-
775	2	Sharqia-W	15.9	0.1	11.1	8.6	13.3	4.9	-	2.7	-	0.3	8.5	16.2	-
775	3	Sharqia-W	-	0.1	8.2	2.7	0.1	-	-	-	-	-	-	-	-
776	1	Sharqia-W	-	-	0.6	2.0	-	-	-	5.8	-	0.5	-	-	6.9
776	2	Sharqia-W	11.8	-	14.8	12.4	13.8	4.6	-	1.5	-	0.3	11.5	20.1	-
776	3	Sharqia-W	1.8	-	-	-	-	-	-	-	-	-	-	-	-
777	1	Sharqia-W	4.0	-	-	-	1.2	5.6	-	-	-	-	9.4	8.0	-
777	2	Sharqia-W	15.7	0.3	13.1	17.1	13.8	3.7	-	1.2	-	0.2	15.2	22.7	-
778	1	Qalyubia	0.3	2.1	0.6	8.5	-	-	-	-	-	-	-	1.9	-
784	2	Beheira-O	1.7	1.8	-	0.2	-	0.7	-	-	-	-	0.1	-	-
784	3	Beheira-O	-	0.1	0.6	-	-	-	-	-	-	-	-	-	6.8
785	1	Beheira-O	-	-	-	-	0.1	1.4	-	-	-	-	-	-	-
785	2	Beheira-O	3.6	0.4	-	-	-	-	-	-	0.4	-	-	-	-
785	3	Beheira-O	-	0.4	-	-	-	-	-	-	-	-	-	-	7.7
786	1	Beheira-O	0.7	-	-	-	0.2	2.1	-	-	-	-	4.9	0.2	-
786	2	Beheira-O	0.4	-	-	1.2	-	6.5	-	-	-	-	5.0	-	-
786	3	Beheira-O	-	0.5	1.7	-	0.2	-	5.5	-	-	-	-	-	10.6
787	2	Beheira-O	14.1	4.6	-	-	-	-	-	-	-	-	-	-	-
787	3	Beheira-O	-	1.5	-	-	0.4	-	-	-	-	-	-	-	7.7
788	1	Beheira-O	2.9	-	8.3	-	24.5	-	19.2	4.3	-	-	0.6	5.7	15.8
788	2	Beheira-O	0.2	6.1	-	2.6	-	8.5	-	-	-	-	2.0	-	-
788	3	Beheira-O	-	2.8	-	-	-	-	4.8	-	-	-	-	-	11.3
789	2	Beheira-O	0.8	0.8	-	-	-	-	-	-	1.6	-	-	-	-
789	3	Beheira-O	-	0.2	-	-	0.1	-	-	-	-	-	-	-	6.7
790	2	Beheira-O	-	0.3	-	0.1	-	1.2	-	-	-	-	-	-	-
790	3	Beheira-O	-	1.1	-	-	0.1	-	-	-	-	-	-	-	6.9
6771	1	Faiyum	1.1	6.1	-	-	0.2	2.7	-	-	-	4.4	-	-	-
6771	3	Faiyum	-	13.2	-	-	0.5	1.3	-	-	-	-	-	-	-
6772	3	Faiyum	0.6	13.2	-	-	-	-	-	-	-	-	-	0.8	-
7821	3	Dakahl.-Da	29.5	-	0.6	19.2	1.8	4.3	-	13.9	-	-	5.1	9.9	-
7822	3	Dakahl.-Da	24.7	-	5.0	23.4	4.7	9.4	-	19.2	-	-	6.6	12.3	-

*)1=2008, 2=2009, 3=2010

Tab. 8.24: Mean deficiency-indices according to PIPPA-evaluation with respect to the 3 different years of sampling 2008 to 2010 for organically grown Egyptian cotton (*Gossypium barbadense*).

Element	Year	N	Mean	Standard deviation	Minimum	Maximum
N	2008	74	2.1	4.5	0.0	23.4
	2009	68	3.8	5.4	0.0	19.5
	2010	66	2.5	8.0	0.0	42.1
	Total	208	2.8	6.1	0.0	42.1
P	2008	74	3.1	6.2	0.0	26.6
	2009	68	2.4	4.6	0.0	19.2
	2010	66	1.5	2.8	0.0	13.2
	Total	208	2.4	4.8	0.0	26.6
S	2008	74	3.1	4.7	0.0	26.1
	2009	68	3.0	4.8	0.0	17.8
	2010	66	2.4	4.3	0.0	19.1
	Total	208	2.9	4.6	0.0	26.1
K	2008	74	2.6	5.7	0.0	35.9
	2009	68	3.7	5.1	0.0	17.1
	2010	66	4.7	8.5	0.0	35.7
	Total	208	3.6	6.6	0.0	35.9
Ca	2008	74	2.4	5.3	0.0	24.5
	2009	68	2.6	4.2	0.0	13.8
	2010	66	1.1	2.6	0.0	13.2
	Total	208	2.0	4.2	0.0	24.5
Mg	2008	74	2.5	3.4	0.0	17.2
	2009	68	1.9	3.1	0.0	17.8
	2010	66	1.5	4.0	0.0	20.2
	Total	208	2.0	3.5	0.0	20.2
Fe	2008	74	2.4	8.8	0.0	35.3
	2009	68	1.4	4.2	0.0	17.3
	2010	66	-0.4	3.1	0.0	16.2
	Total	208	1.2	6.1	0.0	35.3
Mn	2008	74	1.6	5.4	0.0	29.5
	2009	68	-0.8	1.9	0.0	4.9
	2010	66	1.4	4.8	0.0	21.0
	Total	208	0.7	4.5	0.0	29.5
Zn	2008	74	0.3	3.3	0.0	24.6
	2009	68	0.4	2.7	0.0	15.8
	2010	66	0.4	2.9	0.0	14.8
	Total	208	0.4	3.0	0.0	24.6
Cu	2008	74	4.1	6.6	0.0	32.8
	2009	68	0.2	0.8	0.0	5.4
	2010	66	0.1	0.9	0.0	7.1
	Total	208	1.6	4.4	0.0	32.8
B	2008	74	3.0	5.3	0.0	28.8
	2009	68	2.4	3.8	0.0	15.2
	2010	66	0.8	3.0	0.0	21.2
	Total	208	2.1	4.3	0.0	28.8
Mo	2008	74	3.8	6.9	0.0	25.2
	2009	68	4.9	7.4	0.0	22.7
	2010	66	1.9	4.5	0.0	25.3
	Total	208	3.6	6.5	0.0	25.3

Tab. 8.25: Mean deficiency-indices according to PIPPA-evaluation with respect to 7 different sampling regions for organically grown Egyptian cotton (*Gossypium barbadense*) (2008-2010).

Element	Region	n	Mean	Standard deviation	Minimum	Maximum
N	Beheira-W	41	0.9	2.3	0.0	9.7
	Beheira-O	56	2.0	4.8	0.0	23.4
	Sharqia-W	27	3.0	5.2	0.0	15.9
	Sharqia-O	35	3.7	5.3	0.0	19.5
	Dakah.-Dam.	8	15.9	17.7	0.0	42.1
	Qualyubia	14	1.9	4.0	0.0	12.9
	Faiyum	27	2.3	4.6	0.0	20.6
	Total	208	2.8	6.1	0.0	42.1
P	Beheira-W	41	1.0	2.5	0.0	11.3
	Beheira-O	56	1.3	2.0	0.0	10.0
	Sharqia-W	27	0.3	0.7	0.0	3.2
	Sharqia-O	35	1.3	3.4	0.0	18.9
	Dakah.-Dam.	8	0.0	0.0	0.0	0.0
	Qualyubia	14	4.3	6.1	0.0	18.1
	Faiyum	27	9.8	7.7	0.0	26.6
	Total	208	2.4	4.8	0.0	26.6
S	Beheira-W	41	0.3	0.9	0.0	5.0
	Beheira-O	56	1.0	1.9	0.0	8.3
	Sharqia-W	27	7.0	5.8	0.0	17.8
	Sharqia-O	35	6.6	5.4	0.0	26.1
	Dakah.-Dam.	8	4.2	6.9	0.0	19.9
	Qualyubia	14	4.2	5.2	0.0	19.1
	Faiyum	27	0.4	1.1	0.0	4.9
	Total	208	2.9	4.6	0.0	26.1
K	Beheira-W	41	0.3	1.2	0.0	7.7
	Beheira-O	56	0.2	0.7	0.0	3.9
	Sharqia-W	27	5.9	5.2	0.0	17.1
	Sharqia-O	35	7.5	6.9	0.0	35.7
	Dakah.-Dam.	8	9.5	9.1	0.0	23.4
	Qualyubia	14	12.3	11.8	0.0	35.9
	Faiyum	27	2.1	6.2	0.0	26.0
	Total	208	3.6	6.6	0.0	35.9
Ca	Beheira-W	41	0.2	0.3	0.0	1.4
	Beheira-O	56	2.4	6.0	0.0	24.5
	Sharqia-W	27	3.4	5.3	0.0	13.8
	Sharqia-O	35	3.4	3.2	0.0	13.2
	Dakah.-Dam.	8	2.6	2.8	0.0	7.8
	Qualyubia	14	1.2	2.3	0.0	8.2
	Faiyum	27	1.2	3.0	0.0	13.2
	Total	208	2.0	4.2	0.0	24.5
Mg	Beheira-W	41	1.5	2.3	0.0	8.4
	Beheira-O	56	1.5	2.7	0.0	9.8
	Sharqia-W	27	1.5	2.4	0.0	6.9
	Sharqia-O	35	2.1	4.6	0.0	20.2
	Dakah.-Dam.	8	4.1	3.0	0.0	9.4
	Qualyubia	14	3.1	6.5	0.0	18.5
	Faiyum	27	3.0	3.6	0.0	12.4
	Total	208	2.0	3.5	0.0	20.2
Fe	Beheira-W	41	1.6	5.5	0.0	16.1
	Beheira-O	56	3.3	9.8	0.0	35.3
	Sharqia-W	27	-1.1	2.4	0.0	1.6
	Sharqia-O	35	0.2	3.1	0.0	16.2
	Dakah.-Dam.	8	1.9	5.5	0.0	15.6
	Qualyubia	14	0.0	0.0	0.0	0.0
	Faiyum	27	0.0	0.0	0.0	0.0
	Total	208	1.2	6.1	0.0	35.3
Mn	Beheira-W	41	-0.6	2.5	0.0	9.5
	Beheira-O	56	1.2	5.2	0.0	21.0
	Sharqia-W	27	1.4	3.6	0.0	12.6
	Sharqia-O	35	-0.7	1.3	0.0	0.0
	Dakah.-Dam.	8	11.5	10.1	0.0	29.5

Element	Region	n	Mean	Standard deviation	Minimum	Maximum
	Qualyubia	14	1.1	3.5	0.0	13.3
	Faiyum	27	-0.3	0.8	0.0	0.0
	Total	208	0.7	4.5	0.0	29.5
Cu	Beheira-W	41	0.2	1.6	0.0	7.4
	Beheira-O	56	0.3	2.6	0.0	15.8
	Sharqia-W	27	-0.3	1.6	0.0	5.9
	Sharqia-O	35	1.9	5.7	0.0	24.6
	Dakah.-Dam.	8	-0.4	1.0	0.0	0.0
	Qualyubia	14	-0.1	0.4	0.0	0.0
	Faiyum	27	0.0	1.5	0.0	4.0
	Total	208	0.4	3.0	0.0	24.6
Zn	Beheira-W	41	1.0	4.5	0.0	27.9
	Beheira-O	56	0.9	4.1	0.0	22.6
	Sharqia-W	27	1.2	2.4	0.0	8.8
	Sharqia-O	35	2.9	6.1	0.0	32.8
	Dakah.-Dam.	8	0.9	1.6	0.0	4.5
	Qualyubia	14	0.0	0.0	0.0	0.0
	Faiyum	27	3.3	4.7	0.0	17.6
	Total	208	1.6	4.4	0.0	32.8
B	Beheira-W	41	2.1	3.2	0.0	12.4
	Beheira-O	56	2.4	5.8	0.0	28.8
	Sharqia-W	27	2.8	4.9	0.0	15.2
	Sharqia-O	35	3.0	4.2	0.0	21.2
	Dakah.-Dam.	8	3.2	3.4	0.0	7.8
	Qualyubia	14	0.5	1.6	0.0	5.9
	Sharqia-O	27	0.0	0.0	0.0	0.0
	Dakah.-Dam.	208	2.1	4.3	0.0	28.8
Mo	Qualyubia	41	0.4	1.3	0.0	6.0
	Beheira-O	56	2.1	6.1	0.0	25.2
	Sharqia-W	27	5.9	7.8	0.0	22.7
	Sharqia-O	35	8.0	7.5	0.0	21.9
	Dakah.-Dam.	8	8.2	5.5	0.0	13.8
	Qualyubia	14	5.8	8.5	0.0	25.3
	Faiyum	27	0.7	2.1	0.0	9.6
	Total	208	3.6	6.5	0.0	25.3

Tab. 8.26: Excess element concentration with reference to critical values determined according to BOLIDES, determined for 207 tissue samples of Egyptian organically grown cotton (*Gossypium barbadense*) sampled between 2008 and 2010.

Farm no.	Year*)	Site	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo
2	1	Qalyubia	-	-	-	-	6.8	34.8	89.8	16.7	42.7	12.8	31.4	37.8
36	1	Qalyubia	-	4.7	-	-	7.9	14.3	163.2	80.8	107.5	3.7	20.8	-
36	2	Qalyubia	-	33.0	10.5	-	-	-	129.0	-	16.0	21.8	6.2	-
152	1	Beheira-W	-	-	8.5	27.3	15.0	-	-	-	5.5	-	16.7	74.8
163	1	Beheira-W	20.9	47.0	1.3	-	8.5	-	-	-	118.1	17.9	-	14.9
163	2	Beheira-W	-	9.4	21.1	4.2	2.9	-	-	-	15.3	38.1	-	31.3
163	3	Beheira-W	18.0	12.0	3.7	14.7	-	-	20.3	-	46.7	7.5	-	97.5
205	1	Faiyum	1.3	-	8.8	21.0	29.5	-	126.3	126.9	8.0	-	51.9	70.9
205	2	Faiyum	5.7	-	46.5	9.6	0.5	-	86.0	111.9	19.7	18.9	66.5	85.4
205	3	Faiyum	6.0	-	-	-	5.5	-	53.0	37.1	-	7.9	34.9	31.8
241	1	Faiyum	-	-	11.5	11.0	1.7	-	45.1	-	27.0	-	55.5	5.9
241	2	Faiyum	-	-	8.8	7.1	0.7	-	189.9	52.0	-	0.1	76.2	-
241	3	Faiyum	-	-	-	-	-	-	66.7	23.1	-	3.6	29.9	-
256	1	Beheira-W	1.9	-	36.7	21.5	20.5	-	-	-	11.2	1.3	-	75.3
258	1	Qalyubia	-	-	5.7	-	-	-	106.7	-	15.5	5.6	34.7	-
266	1	Beheira-W	9.7	4.8	-	0.4	-	-	30.2	-	32.8	15.3	-	14.5
266	2	Beheira-W	1.9	5.7	3.6	4.2	1.1	-	-	-	9.7	46.8	-	43.2
266	3	Beheira-W	-	9.0	10.9	-	27.8	54.2	12.7	2.7	-	-	18.1	31.0
266	3	Beheira-W	-	6.4	-	5.9	24.7	45.1	2.4	24.2	-	-	23.0	22.3
266	3	Beheira-W	-	-	-	3.9	38.7	28.2	35.3	51.0	-	-	11.8	23.5
273	2	Beheira-W	-	2.2	14.0	4.3	3.3	-	-	-	11.3	30.2	-	32.2
273	3	Beheira-W	10.1	-	16.8	29.8	9.9	13.6	28.1	-	-	7.6	16.3	76.5
273	3	Beheira-W	19.4	12.3	6.8	-	1.0	28.5	8.7	25.5	1.6	-	21.3	23.8
273	3	Beheira-W	18.4	0.2	8.9	-	4.4	7.2	11.1	-	-	-	15.4	114.8
292	1	Faiyum	-	-	7.8	-	23.6	-	85.9	-	-	-	52.8	93.4
292	2	Faiyum	-	-	36.8	28.9	1.5	13.4	110.5	101.3	1.5	6.4	105.0	87.7
292	3	Faiyum	8.6	-	11.5	-	52.6	36.9	99.7	36.3	1.1	17.7	79.0	75.5
308	1	Beheira-W	10.4	-	3.1	-	3.6	-	-	8.0	24.1	23.3	-	88.8
308	2	Beheira-W	-	-	13.8	20.7	18.8	-	-	-	4.1	35.1	-	52.7
308	3	Beheira-W	26.6	25.5	23.0	23.8	6.9	28.1	33.3	-	5.0	1.1	1.6	69.9
311	1	Faiyum	-	-	9.5	3.2	-	-	181.5	84.8	-	-	63.3	46.7
311	2	Faiyum	5.5	-	32.5	5.6	-	9.3	97.1	62.8	9.2	10.2	89.6	74.6
318	1	Faiyum	-	-	9.7	9.0	1.9	-	95.4	29.6	4.4	-	61.6	21.8
318	2	Faiyum	-	-	6.6	-	-	-	85.3	80.1	-	-	84.2	-
444	1	Faiyum	-	-	4.6	11.3	-	-	61.4	-	27.0	-	57.7	-
457	1	Faiyum	-	-	-	13.0	-	-	169.8	41.4	-	-	36.5	14.0
488	1	Faiyum	-	-	23.4	12.3	6.5	-	63.3	3.3	24.8	-	71.0	21.8
488	2	Faiyum	-	-	0.9	10.7	-	-	90.5	104.5	-	8.8	74.9	6.3
488	3	Faiyum	6.2	0.8	7.0	-	-	-	113.5	47.6	126.6	7.2	24.8	13.9
541	1	Beheira-O	22.9	30.4	-	2.3	15.5	-	-	-	77.1	7.9	-	11.2
541	2	Beheira-O	0.6	-	23.2	42.9	3-	9.4	-	-	-	56.2	4.8	48.1
613	1	Faiyum	-	-	11.1	12.6	-	-	57.2	22.1	2.3	-	62.4	13.8
666	1	Faiyum	-	-	-	-	-	-	136.4	36.3	-	-	66.5	-
676	1	Faiyum	-	-	66.6	15.0	51.1	-	184.1	145.9	19.9	-	67.8	93.9
677	1	Faiyum	-	-	44.8	22.0	11.3	5.1	98.2	164.1	0.7	-	87.4	2.1
677	1	Faiyum	-	-	44.8	22.0	11.3	5.1	98.2	164.1	0.7	-	87.4	2.1
677	3	Faiyum	7.3	-	14.5	3.7	-	-	160.5	98.5	9.9	13.4	51.0	87.3
679	1	Dakahl.-Da	6.7	1.8	-	2.7	-	-	37.9	-	0.2	-	-	-
679	2	Dakahl.-Da	0.1	46.0	15.3	-	4.7	-	284.9	28.9	42.7	33.4	39.0	-
679	3	Dakahl.-Da	-	28.4	11.5	-	-	-	69.1	-	3.5	-	2.1	-
680	1	Dakahl.-Da	8.8	16.0	-	2.3	-	-	-	-	17.4	-	-	-
680	2	Dakahl.-Da	0.7	17.6	3.7	-	-	-	240.7	50.7	35.3	27.1	34.8	-
680	3	Dakahl.-Da	-	21.2	-	-	-	-	283.7	-	14.7	3.7	-	-
682	2	Beheira-W	0.3	-	17.3	16.8	17.1	-	-	-	10.8	60.3	-	53.9
682	3	Beheira-W	-	-	-	-	22.6	11.1	92.2	92.0	-	-	-	4.2
683	1	Beheira-W	-	5.8	43.7	22.1	62.0	-	79.7	48.6	47.9	11.7	23.7	-
683	3	Beheira-W	14.2	-	18.1	2.4	11.1	-	7.7	32.7	21.1	9.9	2.1	139.4
685	1	Beheira-W	-	-	5.6	4.4	38.4	19.2	22.2	28.0	1.8	-	78.4	6.2

Farm no.	Year*)	Site	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo
685	2	Beheira-W	2.8	-	10.8	24.6	15.6	-	-	-	13.0	58.7	-	51.3
685	3	Beheira-W	25.5	26.1	6.8	17.0	-	14.3	43.1	-	10.6	10.5	2.6	62.5
686	1	Beheira-W	2.5	-	-	12.3	20.9	24.9	9.7	71.7	38.4	-	17.9	15.8
686	2	Beheira-W	6.8	-	7.1	-	-	5.6	-	47.8	17.1	28.9	-	13.8
688	1	Beheira-W	3.0	1.0	-	15.3	-	-	-	-	32.5	-	-	7.6
688	2	Beheira-W	2.3	-	8.2	11.8	5.5	-	-	-	21.6	58.7	-	50.6
688	3	Beheira-W	2.6	-	-	-	-	-	26.3	1.8	-	2.0	-	17.5
689	1	Beheira-W	17.6	28.5	24.1	8.7	31.2	9.1	2.3	-	58.0	18.9	10.5	27.7
689	3	Beheira-W	15.7	-	2.3	7.5	-	-	21.2	17.2	19.9	16.1	-	59.6
690	1	Beheira-W	3.4	3.1	0.7	13.5	22.0	20.9	-	67.8	58.6	-	15.1	-
690	2	Beheira-W	6.6	-	3.4	-	-	-	-	3.8	20.8	53.2	-	42.5
692	1	Qalyubia	-	-	-	-	-	-	83.2	3.7	45.2	6.8	29.0	-
692	2	Qalyubia	6.3	-	-	-	-	1.3	55.0	39.1	6.8	25.8	33.4	-
692	3	Qalyubia	5.6	-	3.5	-	10.5	12.7	19.5	17.9	0.7	21.4	12.5	-
692	3	Qalyubia	6.2	-	-	-	8.4	-	25.9	7.8	11.4	17.5	10.4	-
692	3	Qalyubia	7.5	10.3	-	-	-	-	51.9	4.2	8.7	15.6	4.1	-
694	2	Qalyubia	-	-	-	-	-	-	112.1	4.2	-	16.3	35.3	-
696	2	Qalyubia	-	-	-	-	11.3	3.3	69.6	2.3	12.4	31.3	10.4	-
696	3	Qalyubia	-	-	-	-	-	-	21.3	-	7.5	4.9	-	-
696	3	Qalyubia	-	13.8	-	-	-	-	26.8	-	24.6	56.1	-	-
710	1	Beheira-O	-	14.4	-	55.5	-	14.4	-	-	-	11.7	1.8	39.7
710	2	Beheira-O	-	-	0.1	5.4	11.2	-	52.4	-	8.4	10.3	3.7	71.9
710	3	Beheira-O	6.1	-	3.9	24.7	6.1	16.6	-	30.8	8.5	16.5	-	90.5
712	3	Beheira-W	12.5	-	-	25.4	-	13.3	21.0	51.1	25.8	27.3	-	65.3
721	2	Beheira-O	-	-	-	43.3	18.6	1.6	5.4	-	-	-	61.1	108.6
721	3	Beheira-O	10.8	-	7.7	29.6	5.9	21.4	-	21.0	11.4	19.7	8.7	106.5
724	1	Beheira-O	-	55.5	-	-	-	-	-	-	24.8	-	-	-
724	2	Beheira-O	-	-	0.6	24.2	49.8	-	109.8	-	-	15.3	27.8	122.6
724	3	Beheira-O	6.5	-	2.9	48.7	3.0	18.2	5.4	29.5	34.1	17.9	8.7	86.2
725	1	Beheira-O	-	37.7	-	79.1	-	26.3	-	-	19.4	-	8.2	36.3
725	2	Beheira-O	-	-	8.0	31.4	66.5	-	146.4	-	-	14.6	48.2	129.3
725	3	Beheira-O	8.8	-	1.7	35.3	6.4	9.6	51.6	41.0	12.6	2-	9.0	104.8
726	2	Beheira-O	-	-	20.2	15.2	26.9	-	60.1	-	11.1	15.5	15.6	84.6
726	3	Beheira-O	3.0	-	7.4	31.4	15.3	19.5	-	54.8	8.2	14.6	8.9	101.3
727	1	Beheira-O	8.3	13.5	-	1.2	-	32.2	294.0	-	32.1	3.0	-	-
727	3	Beheira-O	4.4	-	-	24.9	3.2	18.4	-	46.1	13.1	12.3	1.1	98.2
728	1	Beheira-O	-	41.4	17.1	-	-	-	139.2	-	88.6	5.3	-	-
728	2	Beheira-O	-	-	-	9.4	25.4	-	19.9	-	-	-	-	83.4
728	3	Beheira-O	7.3	-	14.0	21.9	9.3	17.4	-	24.2	27.9	16.1	0.8	108.3
729	1	Beheira-O	14.7	13.6	-	-	-	30.4	333.6	-	28.7	59.2	-	-
729	2	Beheira-O	-	-	-	-	22.2	-	51.1	-	-	6.5	-	43.2
729	3	Beheira-O	9.2	-	1.4	20.7	1.2	15.1	-	28.3	29.4	17.0	0.7	99.6
732	1	Beheira-O	11.0	26.4	-	36.0	-	18.3	-	-	14.9	7.6	0.3	-
732	2	Beheira-O	-	-	15.5	5.9	30.4	-	37.3	-	4.1	19.4	16.2	75.9
732	3	Beheira-O	8.6	-	12.3	33.9	10.2	21.5	-	24.4	7.1	13.8	4.2	104.7
733	1	Beheira-O	-	38.6	3.8	-	-	-	25.8	-	35.6	2.3	-	-
734	1	Beheira-O	18.6	33.3	-	-	8.5	-	-	-	41.6	7.8	-	-
734	2	Beheira-O	4.0	-	9.8	29.6	18.0	-	-	-	8.4	52.3	-	59.7
735	1	Beheira-O	-	52.3	-	-	-	-	-	-	31.0	-	-	-
735	2	Beheira-O	3.7	-	-	7.2	-	-	-	-	8.1	58.8	-	43.4
736	1	Beheira-O	-	-	-	23.1	10.3	12.9	21.8	50.1	58.6	12.6	16.9	29.9
736	2	Beheira-O	9.3	9.1	9.0	-	-	0.3	-	7.9	24.0	22.0	-	29.6
736	3	Beheira-O	3.2	-	-	-	-	-	25.4	-	-	11.1	7.9	43.9
736	3	Beheira-O	13.4	-	-	-	1-	0.1	61.4	-	34.8	17.1	10.9	47.7
737	2	Beheira-W	10.6	2.0	4.9	-	-	7.4	-	14.8	18.1	36.3	-	33.3
739	1	Beheira-W	-	6.1	-	6.8	-	-	9.3	-	45.5	-	-	-
739	2	Beheira-W	7.5	4.7	17.5	12.8	7.0	-	-	12.1	15.4	53.6	-	45.7
740	1	Beheira-W	-	6.1	-	13.5	15.8	6.4	16.3	75.2	2.4	-	1.1	-
740	2	Beheira-W	-	-	20.4	29.7	25.5	-	-	4.3	3.6	56.9	-	54.1
741	1	Beheira-W	-	22.4	-	-	-	-	31.7	-	33.6	18.6	-	-
741	2	Beheira-W	2.8	-	6.6	21.8	16.3	-	-	-	7.0	33.5	-	66.3
743	1	Beheira-O	3.6	23.8	-	35.4	-	12.2	-	-	-	-	-	-
743	3	Beheira-O	8.1	-	-	26.1	-	21.0	-	39.8	29.0	22.8	-	94.1

Farm no.	Year*)	Site	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo
744	2	Beheira-O	9.8	4.9	20.6	2.3	6.3	17.5	-	46.2	2-	25.8	6.2	24.9
745	1	Beheira-W	-	46.2	7.5	6.1	-	-	41.6	-	36.8	5.3	-	-
753	1	Sharqia-W	12.4	-	-	-	3.1	6.8	-	-	8.7	-	14.6	11.2
753	2	Sharqia-W	-	-	-	-	-	-	127.4	-	-	1.0	-	-
753	3	Sharqia-W	15.3	-	-	-	1.5	6.3	8.2	-	6.6	18.2	-	-
754	1	Sharqia-W	-	-	-	-	-	10.4	-	-	-	-	10.3	-
754	2	Sharqia-W	-	-	-	-	-	-	79.6	-	-	-	-	-
754	3	Sharqia-W	18.5	0.2	-	-	23.8	56.2	3.1	-	1.2	27.6	56.3	20.9
755	1	Sharqia-W	3.8	-	-	-	-	-	-	-	4.1	-	-	-
755	2	Sharqia-W	10.6	46.1	-	-	-	1.9	514.3	12.8	42.1	28.6	2.8	-
755	3	Sharqia-W	13.3	-	23.0	-	52.9	63.0	40.6	-	1.0	21.9	62.7	9.8
756	1	Sharqia-W	12.6	13.8	-	-	-	9.0	-	-	22.0	-	2.9	-
756	2	Sharqia-W	2.0	35.6	-	-	-	-	445.7	9.3	30.9	21.3	0.6	-
756	3	Sharqia-W	15.9	6.0	24.8	6.7	32.9	44.8	-	16.2	7.3	7.9	49.1	16.8
757	1	Sharqia-W	12.3	20.8	-	-	1.3	16.0	-	-	-	-	11.5	7.4
757	2	Sharqia-W	5.0	56.2	-	-	-	-	201.3	-	47.5	22.7	-	-
757	3	Sharqia-W	31.0	-	-	-	-	10.8	123.1	-	-	15.0	-	7.3
758	2	Sharqia-W	15.6	48.0	-	-	-	7.6	416.7	1.7	45.6	26.7	9.3	-
758	3	Sharqia-W	26.7	12.6	12.5	-	30.2	28.4	-	51.9	232.8	14.2	23.6	72.3
759	1	Sharqia-O	-	-	-	-	-	-	145.4	19.7	-	-	-	-
759	2	Sharqia-O	-	-	-	-	-	0.2	418.8	8.9	-	-	-	-
759	3	Sharqia-O	-	-	-	16.6	71.5	12.6	87.5	48.5	-	5.5	75.7	-
760	1	Sharqia-O	4.9	9.6	-	-	-	-	48.6	-	12.3	-	-	-
760	2	Sharqia-O	-	-	0.3	-	-	0.8	96.4	-	-	-	7.4	-
760	3	Sharqia-O	-	-	-	26.1	38.4	23.2	44.8	30.9	-	22.9	29.4	26.3
760	3	Sharqia-O	-	-	8.2	-	-	-	-	74.2	12.0	7.7	33.8	-
761	1	Sharqia-O	4.2	-	-	-	-	-	21.2	-	2.3	19.6	-	-
761	2	Sharqia-O	-	13.0	-	-	-	-	26.0	-	3.7	-	-	-
761	3	Sharqia-O	-	6.1	-	-	-	11.6	126.6	31.3	-	2.3	6.4	-
762	1	Sharqia-O	8.3	10.8	-	21.1	-	17.6	36.1	4.9	-	-	10.8	18.1
762	2	Sharqia-O	3.7	32.8	-	-	-	-	73.3	30.8	137.5	22.4	-	-
762	3	Sharqia-O	7.3	13.8	-	0.7	-	3.5	57.7	33.0	-	-	-	-
763	1	Sharqia-O	11.3	8.2	-	-	-	-	88.2	-	7.0	-	-	-
763	2	Sharqia-O	-	8.0	-	-	-	-	287.0	-	3.6	-	2.0	-
764	1	Sharqia-O	-	2.9	-	-	-	-	46.0	62.1	15.5	-	-	-
764	2	Sharqia-O	-	17.0	-	-	-	-	367.9	14.4	-	23.1	-	-
764	3	Sharqia-O	2.6	11.8	-	-	-	3.6	35.0	23.4	4.8	54.3	2.0	17.0
765	1	Sharqia-O	20.5	23.7	-	-	-	-	0.1	-	-	-	-	-
766	2	Sharqia-O	-	-	-	-	-	0.3	47.9	-	-	-	-	-
767	2	Sharqia-O	-	-	-	-	-	2.4	74.0	-	-	-	-	-
768	1	Sharqia-O	-	-	-	-	-	-	2.7	-	-	-	-	13.6
768	2	Sharqia-O	-	-	-	-	-	5.4	943.9	48.8	3.9	15.0	-	-
769	1	Sharqia-O	-	9.4	30.8	3.1	25.2	-	101.8	23.4	5.6	-	14.5	-
769	2	Sharqia-O	-	-	-	-	-	-	53.6	-	-	4.3	-	-
770	1	Sharqia-O	-	11.1	-	-	-	-	4.9	30.1	-	-	-	-
770	2	Sharqia-O	-	-	-	-	-	-	71.3	-	-	4.8	-	-
770	3	Sharqia-O	4.4	61.4	-	-	-	-	290.5	33.0	31.9	22.3	-	34.4
771	1	Sharqia-O	0.9	22.7	-	-	-	1.9	3.1	43.2	-	-	-	-
771	2	Sharqia-O	-	-	-	-	-	-	128.2	-	2.3	13.0	-	-
772	1	Sharqia-O	-	26.2	-	-	-	-	0.9	36.1	-	-	-	-
772	2	Sharqia-O	-	-	-	-	-	-	84.8	-	-	-	-	-
772	3	Sharqia-O	11.1	13.6	-	-	-	3.7	45.2	19.3	17.3	21.8	3.9	-
773	1	Sharqia-O	-	19.2	-	-	-	-	-	28.2	-	-	-	-
773	3	Sharqia-O	18.1	18.0	-	-	-	-	152.9	34.4	22.6	15.2	6.4	10.2
774	1	Sharqia-W	-	-	-	-	-	-	36.5	-	34.6	4.1	0.8	-
774	2	Sharqia-W	-	4.2	-	-	-	-	69.6	-	-	1.7	-	-
775	1	Sharqia-W	8.2	14.2	-	-	-	9.6	14.5	-	16.5	-	9.1	-
775	2	Sharqia-W	-	-	-	-	-	-	42.7	-	-	-	-	-
775	3	Sharqia-W	24.6	-	-	-	-	9.0	58.9	-	32.7	24.0	17.6	68.5
776	1	Sharqia-W	23.9	30.4	-	-	8.1	11.3	-	-	18.5	-	4.1	19.8
776	2	Sharqia-W	-	4.5	-	-	-	-	26.4	-	-	-	-	-
776	3	Sharqia-W	-	-	8.8	16.1	50.7	44.4	158.1	32.7	-	15.9	55.9	49.1
777	1	Sharqia-W	-	41.6	5.0	4.1	-	-	42.3	-	100.8	13.4	-	-

Farm no.	Year*)	Site	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo
777	2	Sharqia-W	-	-	-	-	-	-	33.9	-	3.6	-	-	-
778	1	Qalyubia	-	-	-	-	1-	5.3	8-	43.9	51.0	2.7	19.6	-
784	2	Beheira-O	-	-	6.3	-	22.0	-	37.7	-	-	15.6	-	79.2
784	3	Beheira-O	8.1	-	-	18.3	7.3	19.8	-	49.4	21.2	26.9	3.5	100.2
785	1	Beheira-O	1.0	23.5	41.1	5.1	-	-	119.4	-	82.8	-	35.0	89.3
785	2	Beheira-O	-	-	21.6	47.8	49.2	25.4	76.3	30.4	-	7.2	146.5	105.6
785	3	Beheira-O	10.4	-	9.8	32.4	11.0	21.5	-	35.2	23.1	27.0	4.6	110.6
786	1	Beheira-O	-	14.3	5.1	6.0	-	-	2-	-	35.6	0.9	-	-
786	2	Beheira-O	-	2.2	28.5	-	34.8	-	84.0	15.3	16.7	25.4	-	36.7
786	3	Beheira-O	6.2	-	-	18.1	-	12.9	-	44.7	8.7	19.6	2.2	86.1
787	2	Beheira-O	-	-	15.7	42.8	58.6	6.0	175.2	8.1	-	21.0	82.9	107.3
787	3	Beheira-O	7.8	-	0.9	27.7	-	13.8	-	32.4	3.9	26.1	1.0	84.7
788	1	Beheira-O	-	25.1	-	37.3	-	18.7	-	-	-	10.9	-	-
788	2	Beheira-O	-	-	2.7	-	24.7	-	79.9	3.2	0.3	22.2	-	75.2
788	3	Beheira-O	7.5	-	5.5	39.2	8.7	19.2	-	39.3	8.0	25.1	4.2	104.4
789	2	Beheira-O	-	-	7.1	28.9	29.0	8.0	32.2	4.1	-	6.8	73.2	86.6
789	3	Beheira-O	7.1	-	3.7	25.2	-	26.1	-	38.1	6.2	21.5	0.7	72.5
790	2	Beheira-O	3.5	-	15.9	-	33.5	-	96.4	8.2	1.2	23.1	4.9	72.3
790	3	Beheira-O	11.4	-	3.6	29.2	-	15.8	-	26.2	17.5	27.9	7.4	97.6
6771	1	Faiyum	-	-	26.7	4.0	-	-	128.0	96.9	3.0	-	64.3	-
6771	3	Faiyum	8.9	-	24.8	16.5	-	-	289.7	205.0	281.0	87.4	69.7	34.0
6772	3	Faiyum	-	-	25.7	7.5	3.0	1.6	192.0	52.1	18.1	12.8	96.8	-
7821	3	Dakahl.-Da	-	2-	-	-	-	-	91.9	-	2.9	-	-	-
7822	3	Dakahl.-Da	-	1-	-	-	-	-	76.6	-	-	7.4	-	-

*)1=2008, 2=2009, 3=2010.

Tab. 8.27: **Mean excess element concentration with reference to critical values determined according to BOLIDES evaluation system for the 3 different years of sampling for organically grown cotton (*Gossypium barbadense*).**

Element	Year	N	Mean	Standard deviation	Minimum	Maximum
N	2008	74	3.9	6.4	0.0	24
	2009	68	1.9	3.4	0.0	16
	2010	66	8.4	7.8	0.0	31
	Total	208	4.7	6.7	0.0	31
P	2008	74	12.2	15.2	0.0	55
	2009	68	5.9	13.3	0.0	56
	2010	66	5.1	10.3	0.0	61
	Total	208	7.9	13.5	0.0	61
S	2008	74	6.9	13.8	0.0	67
	2009	68	7.6	10.3	0.0	46
	2010	66	5.3	7.4	0.0	26
	Total	208	6.6	10.9	0.0	67
K	2008	74	8.4	14.0	0.0	79
	2009	68	8.1	13.0	0.0	48
	2010	66	10.8	13.4	0.0	49
	Total	208	9.1	13.4	0.0	79
Ca	2008	74	6.4	12.2	0.0	62
	2009	68	10.1	15.8	0.0	66
	2010	66	9.5	15.8	0.0	71
	Total	208	8.6	14.6	0.0	71
Mg	2008	74	5.3	8.9	0.0	35
	2009	68	1.9	4.5	0.0	25
	2010	66	14.0	15.5	0.0	63
	Total	208	6.9	11.6	0.0	63
Fe	2008	74	52.4	68.8	0.0	334
	2009	68	106.6	156.4	0.0	944
	2010	66	51.2	69.8	0.0	290
	Total	208	69.7	108.5	0.0	944
Mn	2008	74	22.4	39.6	0.0	164

Element	Year	N	Mean	Standard deviation	Minimum	Maximum
	2009	68	14.3	26.7	0.0	112
	2010	66	28.2	31.7	0.0	205
	Total	208	21.6	33.7	0.0	205
Zn	2008	74	23.8	27.8	0.0	118
	2009	68	10.8	19.8	0.0	138
	2010	66	19.9	46.2	0.0	281
	Total	208	18.3	33.1	0.0	281
Cu	2008	74	4.2	8.8	0.0	59
	2009	68	20.5	18.5	0.0	60
	2010	66	15.6	14.4	0.0	87,4
	Total	208	13.1	15.9	0.0	87,4
B	2008	74	17.9	25.8	0.0	87
	2009	68	17.2	32.0	0.0	146
	2010	66	15.7	22.8	0.0	97
	Total	208	17.0	27.0	0.0	146
Mo	2008	74	13.9	25.4	0.0	94
	2009	68	34.0	38.2	0.0	129
	2010	66	47.3	42.4	0.0	139
	Total	208	31.1	38.2	0.0	139

Tab. 8.28: **Mean excess element concentration with reference to critical values determined according to BOLIDES evaluation system for the 7 different regions for organically grown cotton (*Gossypium barbadense*).**

Element	Site	N	Mean	Standard deviation	Minimum	Maximum
N	Beheira-W	41.0	6.7	8.0	0.0	27
	Beheira-O	56.0	4.6	5.4	0.0	23
	Sharqia-W	27.0	9.3	9.7	0.0	31
	Sharqia-O	35.0	2.8	5.2	0.0	20
	Dakahlia-Da.	8.0	2.0	3.6	0.0	9
	Qalyubila	14.0	1.8	3.0	0.0	7
	Faiyum	27.0	1.8	3.1	0.0	9
	Total	208.0	4.7	6.7	0.0	31
P	Beheira-W	41.0	6.8	12.0	0.0	47
	Beheira-O	56.0	8.3	14.7	0.0	55
	Sharqia-W	27.0	12.4	18.0	0.0	56
	Sharqia-O	35.0	9.7	12.8	0.0	61
	Dakahlia-Da.	8.0	20.1	13.1	1.8	46
	Qalyubila	14.0	4.4	9.4	0.0	33
	Faiyum	27.0	0.0	0.1	0.0	1
	Total	208.0	7.9	13.5	0.0	61
S	Beheira-W	41.0	9.2	10.2	0.0	44
	Beheira-O	56.0	6.2	8.8	0.0	41
	Sharqia-W	27.0	2.7	6.8	0.0	25
	Sharqia-O	35.0	1.1	5.4	0.0	31
	Dakahlia-Da.	8.0	3.8	6.1	0.0	15
	Qalyubila	14.0	1.4	3.1	0.0	11
	Faiyum	27.0	18.0	17.5	0.0	67
	Total	208.0	6.6	10.9	0.0	67
K	Beheira-W	41.0	10.4	9.9	0.0	30
	Beheira-O	56.0	19.8	18.3	0.0	79
	Sharqia-W	27.0	1.0	3.4	0.0	16
	Sharqia-O	35.0	1.9	6.1	0.0	26
	Dakahlia-Da.	8.0	0.6	1.2	0.0	3
	Qalyubila	14.0	0.0	0.0	0.0	0
	Faiyum	27.0	9.1	8.1	0.0	29
	Total	208.0	9.1	13.4	0.0	79
Ca	Beheira-W	41.0	12.1	13.9	0.0	62
	Beheira-O	56.0	12.3	16.2	0.0	66
	Sharqia-W	27.0	7.6	15.8	0.0	53
	Sharqia-O	35.0	3.9	14.0	0.0	71
	Dakahlia-Da.	8.0	0.6	1.7	0.0	5
	Qalyubila	14.0	3.9	4.8	0.0	11

Element	Site	N	Mean	Standard deviation	Minimum	Maximum
	Faiyum	27.0	7.4	14.8	0.0	53
	Total	208.0	8.6	14.6	0.0	71
Mg	Beheira-W	41.0	8.2	13.2	0.0	54
	Beheira-O	56.0	9.7	10.1	0.0	32
	Sharqia-W	27.0	12.4	18.3	0.0	63
	Sharqia-O	35.0	2.5	5.4	0.0	23
	Dakahlia-Da.	8.0	0.0	0.0	0.0	0
	Qalyubila	14.0	5.1	9.8	0.0	35
	Faiyum	27.0	2.6	7.6	0.0	37
	Total	208.0	6.9	11.6	0.0	63
Fe	Beheira-W	41.0	14.6	21.3	0.0	92
	Beheira-O	56.0	38.8	69.0	0.0	334
	Sharqia-W	27.0	90.5	143.6	0.0	514
	Sharqia-O	35.0	114.6	176.9	0.0	944
	Dakahlia-Da.	8.0	135.6	115.3	0.0	285
	Qalyubila	14.0	73.9	43.9	19.5	163
	Faiyum	27.0	117.2	56.0	45.1	290
	Total	208.0	69.7	108.5	0.0	944
Mn	Beheira-W	41.0	16.6	25.6	0.0	92
	Beheira-O	56.0	13.9	18.2	0.0	55
	Sharqia-W	27.0	4.6	11.9	0.0	52
	Sharqia-O	35.0	19.4	20.5	0.0	74
	Dakahlia-Da.	8.0	9.9	19.3	0.0	51
	Qalyubila	14.0	15.8	23.6	0.0	81
	Faiyum	27.0	71.4	55.9	0.0	205
	Total	208.0	21.6	33.7	0.0	205
Zn	Beheira-W	41.0	19.5	22.7	0.0	118
	Beheira-O	56.0	18.3	21.0	0.0	89
	Sharqia-W	27.0	24.3	47.6	0.0	233
	Sharqia-O	35.0	8.1	23.7	0.0	138
	Dakahlia-Da.	8.0	14.6	16.5	0.0	43
	Qalyubila	14.0	25.0	28.9	0.0	107
	Faiyum	27.0	21.7	57.4	0.0	281
	Total	208.0	18.3	33.1	0.0	281
Cu	Beheira-W	41.0	19.1	20.5	0.0	60
	Beheira-O	56.0	16.4	14.1	0.0	59
	Sharqia-W	27.0	9.8	10.8	0.0	29
	Sharqia-O	35.0	7.3	11.8	0.0	54
	Dakahlia-Da.	8.0	9.0	13.5	0.0	33
	Qalyubila	14.0	17.3	14.2	2.7	56
	Faiyum	27.0	7.2	17.1	0.0	87
	Total	208.0	13.1	15.9	0.0	87
B	Beheira-W	41.0	6.7	13.9	0.0	78
	Beheira-O	56.0	11.4	25.6	0.0	146
	Sharqia-W	27.0	12.3	19.7	0.0	63
	Sharqia-O	35.0	5.5	14.5	0.0	76
	Dakahlia-Da.	8.0	9.5	17.0	0.0	39
	Qalyubila	14.0	17.7	13.2	0.0	35
	Faiyum	27.0	65.5	19.9	24.8	105
	Total	208.0	17.0	27.0	0.0	146
Mo	Beheira-W	41.0	41.6	33.4	0.0	139
	Beheira-O	56.0	61.4	41.7	0.0	129
	Sharqia-W	27.0	10.5	20.4	0.0	72
	Sharqia-O	35.0	3.4	8.4	0.0	34
	Dakahlia-Da.	8.0	0.0	0.0	0.0	0
	Qalyubila	14.0	2.7	10.1	0.0	38
	Faiyum	27.0	32.7	35.9	0.0	94
	Total	208.0	31.1	38.2	0.0	139
	Total	208.0	87.8	150.8	0.0	1,308

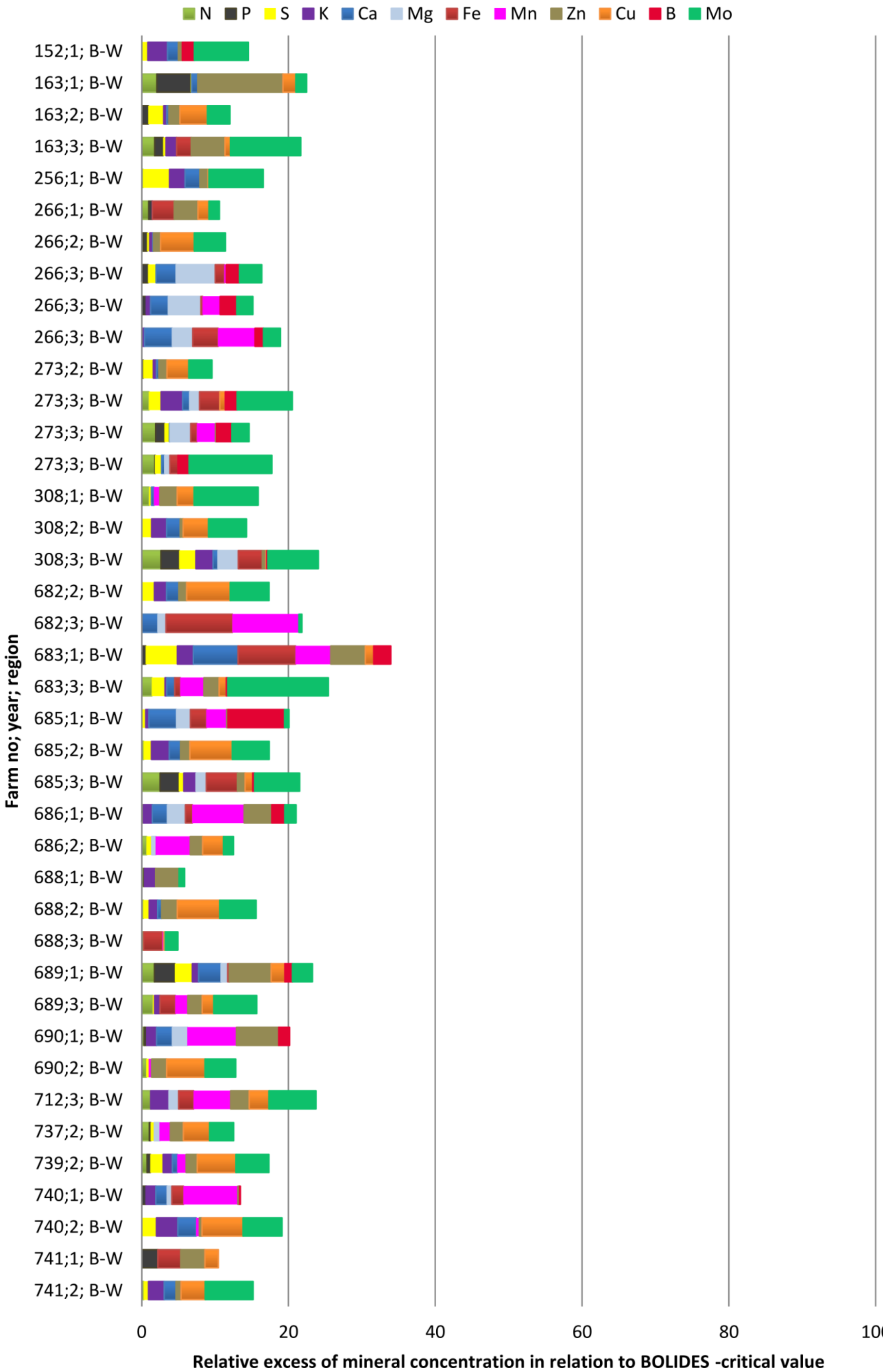


Fig. 8.8: Relative concentration of nutrients exceeding critical values determined by BOLIDES in young, fully developed main stem leaves of organically grown cotton (*Gossypium barbadense)*, sampled in 2008-2010. Year: 1=2008, 2=2009, 3=2010; region: B-W=Beheira-west, B-O=Beheira-east, S-W=Sharqia-west, S-O=Sharqia-east, Dah=Dakahlia/Damietta, Qal=Qalyubia,Fai=Faiyum.

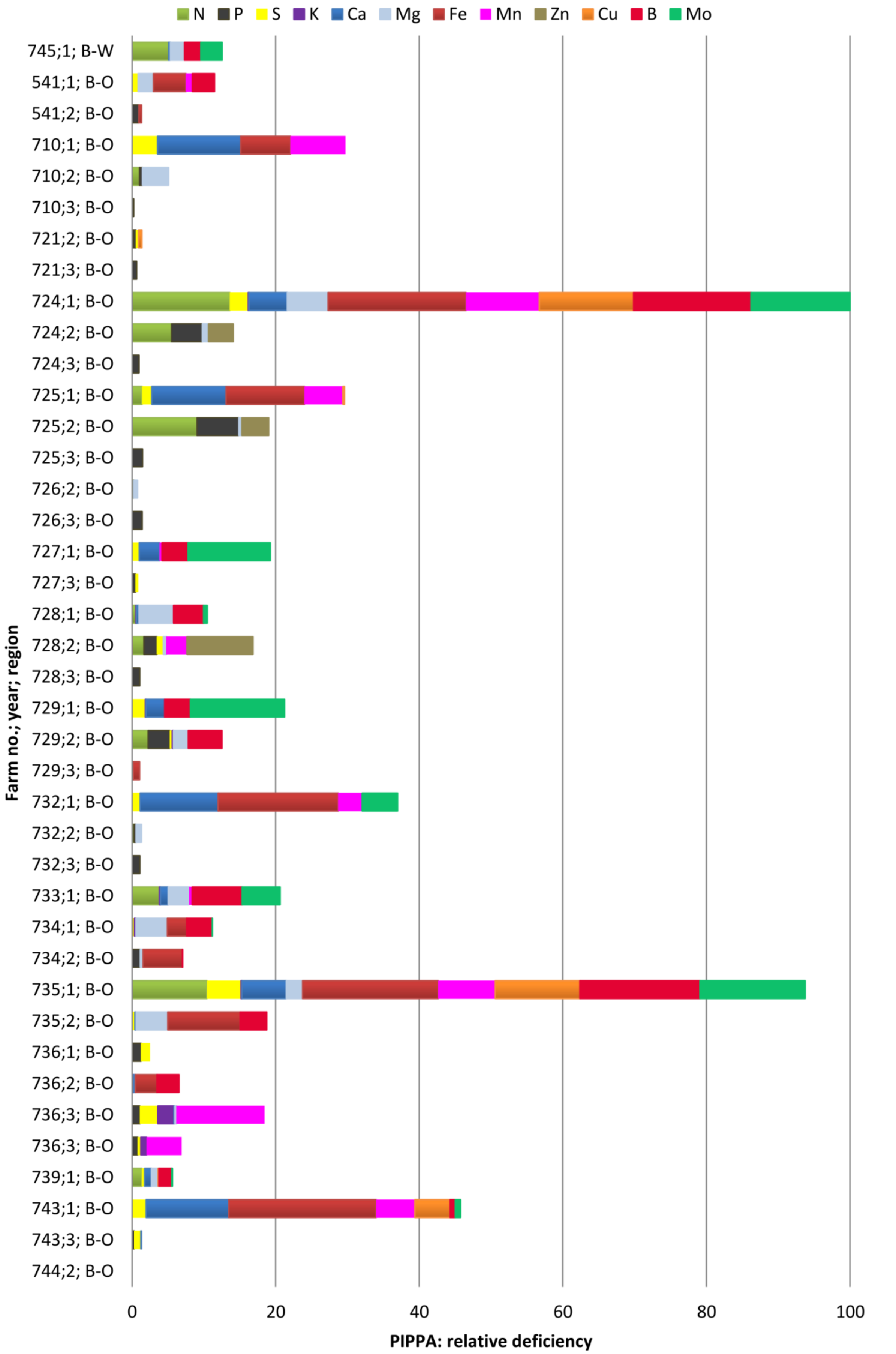


Fig. 8.8 continued

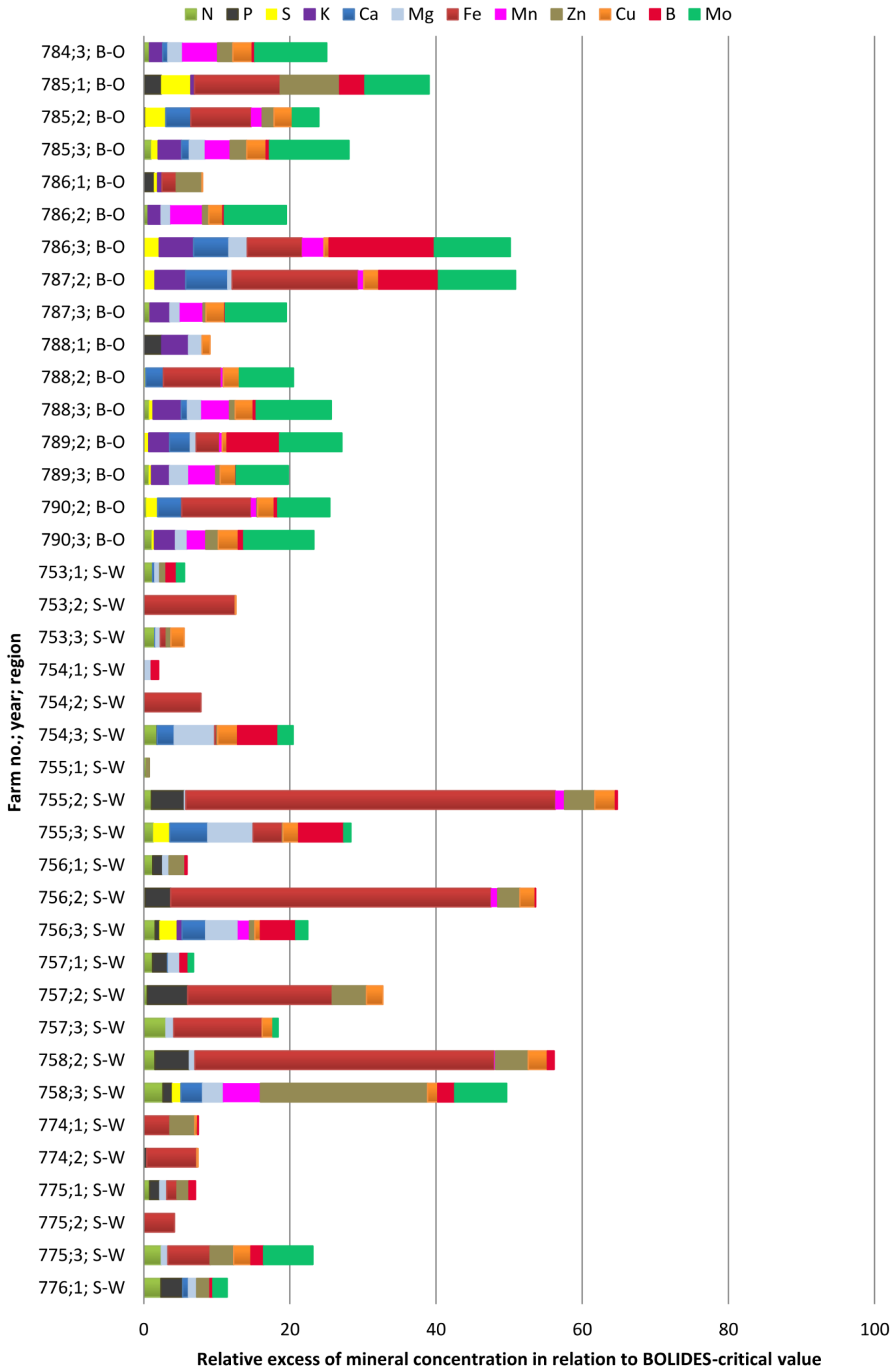


Fig. 8.8 continued

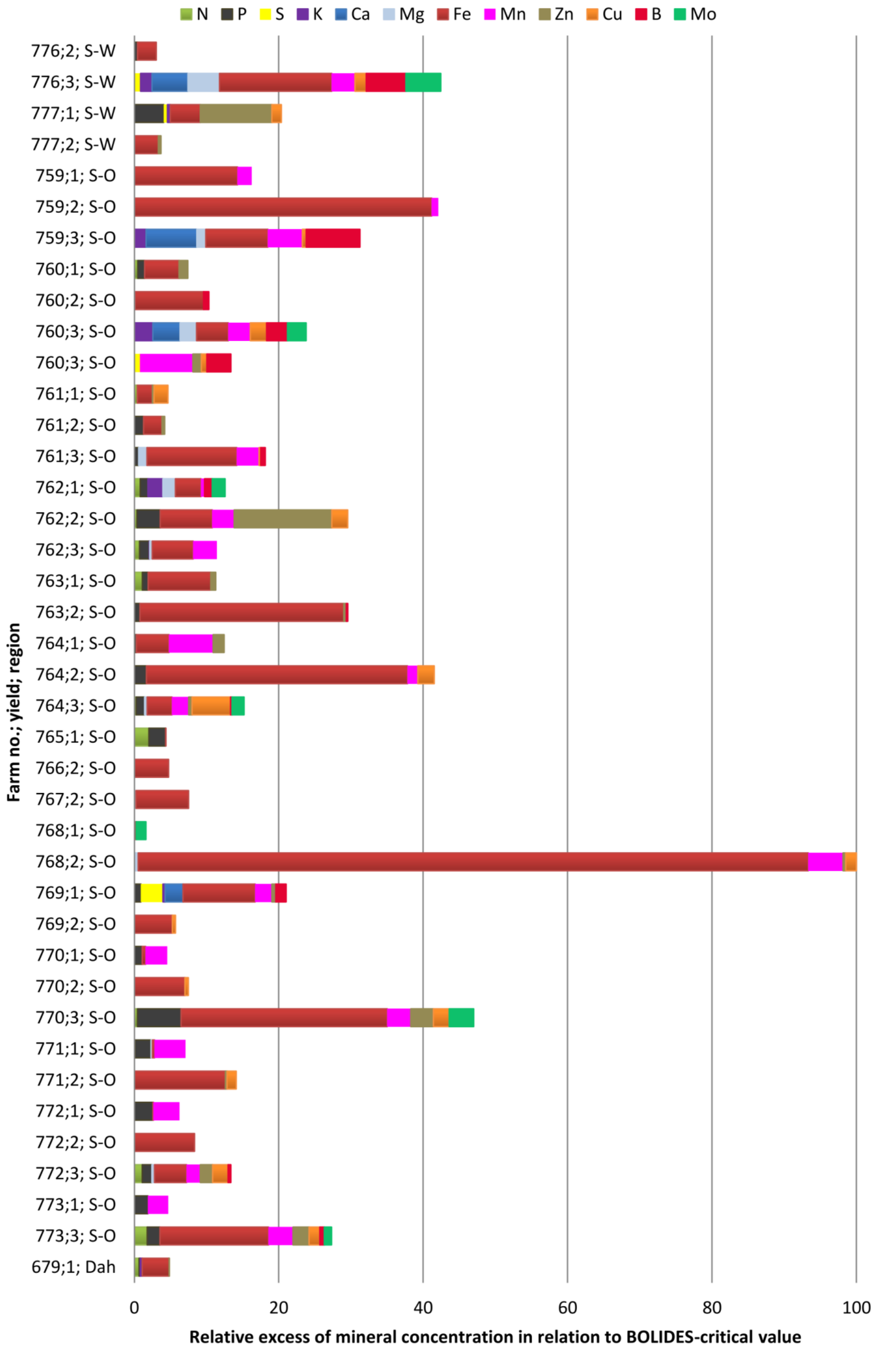


Fig. 8.8 continued

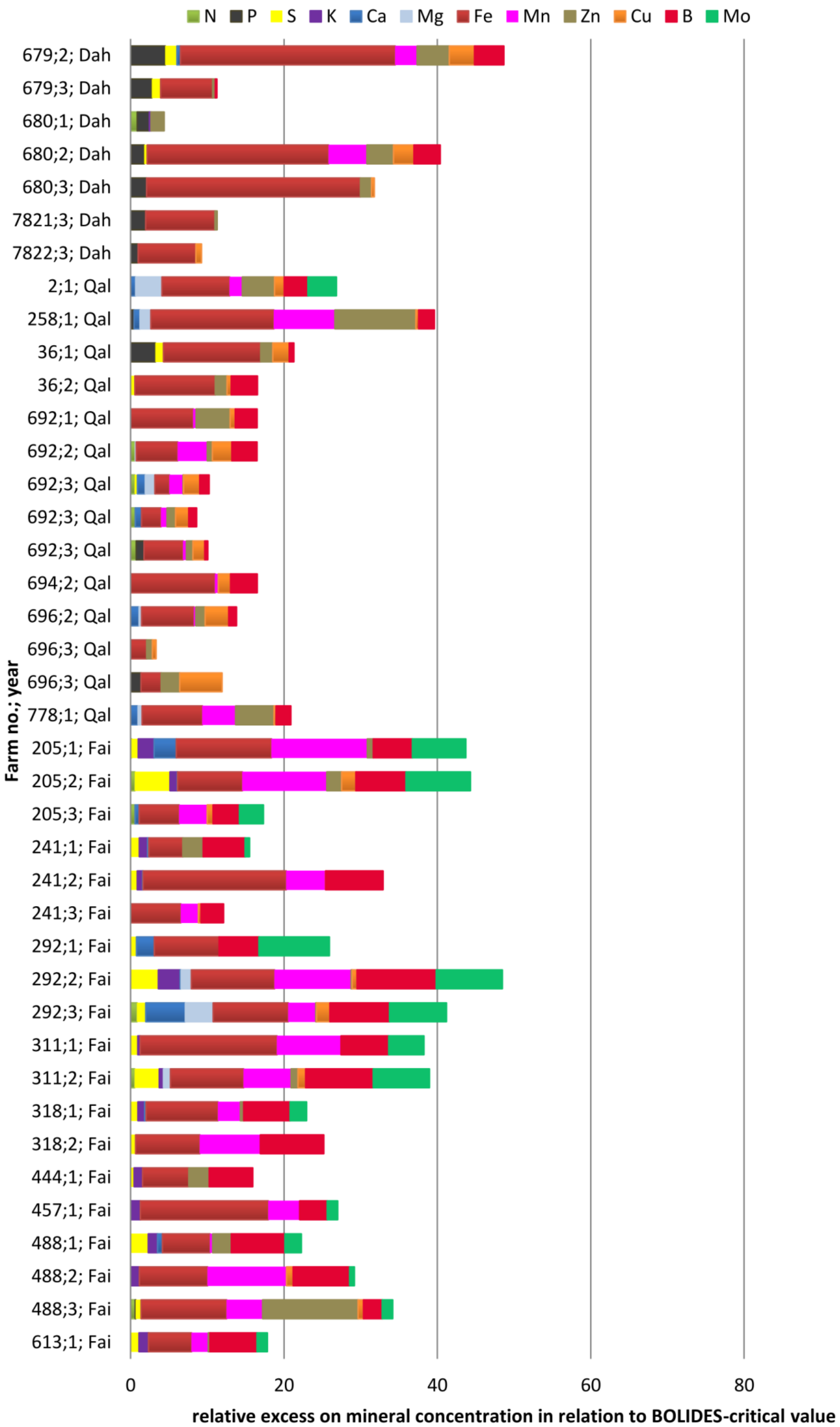


Fig. 8.8 continued

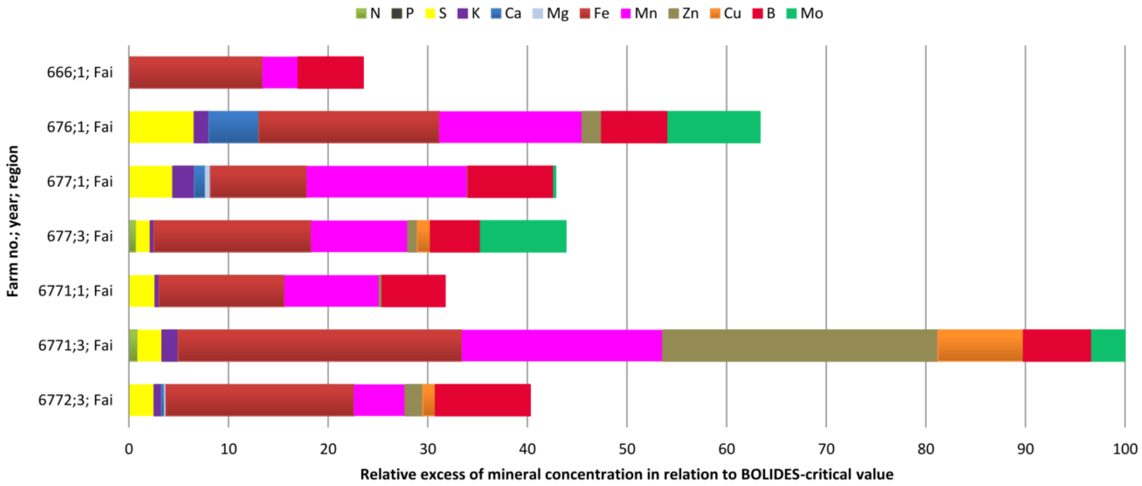


Fig. 8.8 continued

Tab. 8.29: DRIS-indices according to Walworth and Sumner (1987) for element-concentrations in 207 samples of young, fully developed main stem leaf blades of organically grown cotton (*Gossypium barbadense*), sampled in 2008-2010.

Farm no.	Year*)	Site	N	P	S	K	Ca	Mg	B	Mo	Fe	Mn	Cu	Zn
2	1	Qualyubia	5.30	-42.65	-10.39	-61.30	9.35	23.55	19.64	14.11	31.63	16.52	6.46	16.53
36	1	Qualyubia	-7.39	-3.76	-14.01	-23.00	0.85	3.81	4.81	-29.54	42.54	33.50	-8.79	28.79
36	2	Qualyubia	-3.37	13.35	4.88	-10.31	0.96	-20.02	1.27	-17.61	35.49	-11.41	4.16	-2.07
152	1	Beheira-W	-0.31	-26.78	5.47	8.32	10.56	1.44	8.81	23.72	-15.88	-12.03	-11.26	-5.54
163	3	Beheira-W	8.17	1.81	-0.51	-0.68	-3.22	-5.38	-4.00	26.80	-5.35	-31.09	-4.21	7.93
163	1	Beheira-W	12.13	19.41	-0.59	-10.29	4.83	-13.82	-13.51	-2.66	-40.33	-16.35	1.66	36.68
163	2	Beheira-W	-3.73	2.85	9.53	-3.23	3.02	-6.94	-11.32	5.22	-22.06	-10.14	10.60	-2.07
205	3	Faiyum	6.03	-15.61	-2.09	-5.00	5.99	-13.40	16.00	7.27	11.15	20.23	-0.31	-16.45
205	1	Faiyum	-2.57	-34.23	-0.80	-0.70	10.98	-14.02	16.79	15.39	29.38	51.60	-17.56	-11.63
205	2	Faiyum	-4.47	-40.05	12.94	-9.15	-6.05	-6.96	19.46	17.46	12.51	39.80	-5.00	-8.57
241	2	Faiyum	-11.18	-29.04	3.34	-3.30	1.11	-3.64	33.38	-24.04	57.83	25.52	-7.37	-17.43
241	3	Faiyum	-1.65	-7.94	-2.16	-10.48	-15.91	-2.59	22.65	-17.61	23.57	21.00	3.57	-3.29
241	1	Faiyum	-2.50	-8.41	5.16	-0.28	2.41	-10.64	22.55	-4.45	6.02	-3.66	-13.22	2.52
256	1	Beheira-W	4.32	-18.40	19.45	6.47	13.94	-8.55	0.39	24.14	-45.22	-15.33	-3.83	-2.66
258	1	Qualyubia	-3.89	-19.15	9.08	-15.24	7.30	4.25	22.06	-58.09	37.38	-4.92	3.04	4.00
266	3	Beheira-W	-4.11	-6.60	-4.51	-5.83	16.30	11.51	2.61	0.61	0.41	21.23	-8.16	-23.64
266	3	Beheira-W	-3.33	-1.20	-3.59	-5.23	10.06	18.59	7.63	0.50	-14.72	9.34	-12.92	-17.67
266	3	Beheira-W	-4.16	0.32	2.81	-12.49	11.57	22.74	5.80	3.92	-9.35	-0.24	-10.67	-29.24
266	1	Beheira-W	4.97	0.62	-2.99	-4.87	-3.32	0.32	-4.92	-0.57	0.68	-5.18	1.28	4.62
266	2	Beheira-W	1.00	3.14	3.63	-1.36	4.18	-6.12	-7.52	11.87	-44.64	-3.15	16.57	-2.70
273	2	Beheira-W	-2.94	2.46	9.56	-0.26	6.28	-1.80	-8.74	8.80	-43.30	-14.45	10.74	-0.93
273	3	Beheira-W	8.30	-4.11	1.62	-9.61	1.05	2.14	3.98	32.29	-9.92	-8.63	-8.47	-13.82
273	3	Beheira-W	7.56	0.88	-0.10	-10.57	-1.30	10.84	6.09	0.36	-11.84	9.02	-9.45	-12.10
273	3	Beheira-W	2.55	-19.55	4.46	4.51	3.42	4.88	4.28	18.70	-3.22	-7.92	-5.27	-16.59
292	2	Faiyum	-7.28	-64.34	10.80	1.18	-4.13	2.09	37.87	21.62	22.60	38.94	-10.48	-18.11
292	1	Faiyum	5.16	-51.87	10.96	-34.18	19.92	2.47	30.79	37.82	31.06	2.10	-19.14	-6.19
292	3	Faiyum	3.67	-35.07	3.16	-59.25	21.43	14.35	29.09	18.71	24.29	16.58	-0.24	-14.44
308	3	Beheira-W	6.82	2.83	3.31	-1.51	-1.62	7.23	-5.61	12.32	-4.84	-7.74	-12.25	-14.19
308	1	Beheira-W	6.24	-4.09	1.87	-12.09	3.48	-7.50	-12.19	25.87	-17.83	5.18	5.36	2.02
308	2	Beheira-W	-3.37	-7.57	4.81	2.55	8.75	-2.81	-6.27	11.40	-22.26	-2.10	7.87	-8.81
311	2	Faiyum	-0.84	-53.91	10.48	-8.29	-5.52	1.49	32.85	18.06	19.73	24.54	-6.21	-10.93
311	1	Faiyum	1.52	-60.09	6.12	-3.64	1.10	-3.68	31.43	14.74	59.93	44.96	-17.45	-24.11
318	1	Faiyum	-0.75	-25.73	5.25	-0.64	3.29	-11.74	26.91	2.80	25.22	15.77	-16.03	-7.16
318	2	Faiyum	-2.79	-44.26	5.19	-6.10	-0.08	1.53	41.08	-9.32	24.50	42.69	-7.37	-21.14
444	1	Faiyum	-1.17	-11.70	2.96	0.79	0.63	-9.28	25.29	-7.65	12.99	-6.13	-12.49	3.53
457	1	Faiyum	-2.46	-59.94	-1.33	6.48	2.06	3.32	24.49	5.17	62.82	29.00	-13.05	-15.40
488	1	Faiyum	-1.38	-12.24	8.14	-2.13	2.36	-12.88	25.82	-0.26	9.97	-0.10	-16.00	-0.72
488	3	Faiyum	0.47	-5.46	-0.64	-24.48	-16.56	-8.19	6.84	-5.07	25.91	18.94	-6.45	34.95
488	2	Faiyum	1.90	-47.08	1.01	0.34	-18.22	-0.98	37.01	-2.67	25.13	52.54	-0.98	-15.61
541	2	Beheira-O	-6.67	-14.61	6.62	8.87	11.46	2.17	-1.79	8.24	-34.22	-5.96	13.38	-15.51
541	1	Beheira-O	14.26	12.87	-4.30	-4.33	9.39	-6.93	-9.71	-2.82	-37.52	-13.39	-1.86	22.29
613	1	Faiyum	-1.58	-14.92	6.18	1.45	-0.02	-8.34	27.71	0.14	11.71	12.35	-19.94	-7.64
666	1	Faiyum	-8.31	-20.32	0.10	-2.12	1.25	-3.70	38.42	-31.43	49.73	26.40	-19.78	-4.80
676	1	Faiyum	-10.56	-39.04	17.93	-11.00	13.32	-14.51	15.93	16.13	38.93	49.38	-26.14	-13.18
677	1	Faiyum	-8.30	-21.54	12.94	-2.99	-0.17	-3.63	28.82	-14.55	17.24	62.56	-27.82	-18.91
677	3	Faiyum	-2.85	-18.66	-0.53	-11.52	-12.38	-6.48	14.43	18.84	36.14	35.53	-6.95	-12.60
677	1	Faiyum	-8.30	-21.54	12.94	-2.99	-0.17	-3.63	28.82	-14.55	17.24	62.56	-27.82	-18.91
679	2	Dakah.-Da.	-6.26	14.03	2.04	-24.49	-1.94	-19.18	10.40	-58.16	80.79	9.45	4.03	3.79
679	1	Dakah.-Da.	15.59	8.00	-14.72	4.56	-6.81	4.72	0.13	-10.13	12.82	-17.67	-5.66	-0.65
679	3	Dakah.-Da.	-17.34	20.24	13.52	-17.12	7.28	1.56	7.21	-36.26	24.15	-29.42	-4.86	-0.67
680	2	Dakah.-Da.	-5.56	1.46	-3.56	-23.05	-4.32	-7.92	9.03	-28.39	65.13	18.66	1.35	0.85
680	1	Dakah.-Da.	17.51	15.95	-3.25	4.75	-2.06	4.29	-1.47	1.12	-34.27	-57.27	-1.39	7.98
680	3	Dakah.-Da.	-17.65	13.85	1.73	-29.77	-2.28	-2.94	0.76	-46.26	107.44	-15.14	-0.08	1.51

Farm no.	Year*)	Site	N	P	S	K	Ca	Mg	B	Mo	Fe	Mn	Cu	Zn
682	3	Beheira-W	-3.28	-11.04	-6.97	-18.59	16.16	9.95	-2.28	-3.04	28.92	50.65	-14.33	-19.02
682	2	Beheira-W	-5.44	-7.92	5.84	0.32	7.49	-2.38	-6.38	11.47	-32.70	-6.41	16.91	-6.33
683	3	Beheira-W	3.21	-8.02	3.48	-9.08	1.92	-4.96	-4.44	36.43	-14.00	10.65	-5.73	-4.48
683	1	Beheira-W	-17.04	-4.80	13.17	-1.19	21.99	-16.01	3.01	-32.11	11.92	16.21	-6.17	4.77
685	3	Beheira-W	7.57	4.37	-2.19	-2.83	-5.74	2.94	-3.70	11.38	0.05	-4.48	-5.85	-9.42
685	1	Beheira-W	-1.40	-31.26	3.52	-2.92	21.03	11.52	35.48	-3.83	-2.02	15.66	-33.20	-8.75
685	2	Beheira-W	-2.93	-11.29	3.68	4.36	7.79	-5.93	-3.28	11.43	-35.51	-1.09	17.25	-4.63
686	1	Beheira-W	-0.61	-8.43	-5.50	-2.73	8.02	9.51	4.79	-2.90	-11.38	28.68	-15.00	3.92
686	2	Beheira-W	2.87	-4.94	3.17	-6.33	0.66	3.95	-4.18	-0.98	-39.07	22.25	6.94	-1.45
688	3	Beheira-W	6.47	0.34	0.67	-6.13	0.19	-4.25	-3.85	4.06	3.37	5.71	-0.35	-8.85
688	1	Beheira-W	3.30	0.05	-0.04	2.74	-0.55	0.68	-4.39	-2.01	-13.51	-2.18	-4.88	5.70
688	2	Beheira-W	-2.69	-4.42	3.03	-0.54	3.62	-8.27	-7.32	11.49	-30.86	-1.33	17.90	-0.22
689	3	Beheira-W	6.91	-5.90	-0.48	-3.08	-3.03	-1.54	-10.20	14.10	-4.09	7.13	0.28	-1.59
689	1	Beheira-W	2.26	4.43	4.19	-7.51	8.28	-1.04	-2.15	-1.98	-18.89	-14.41	-3.25	7.12
690	2	Beheira-W	2.07	-2.74	2.18	-5.62	-1.12	-2.25	-8.66	10.46	-35.66	3.28	17.53	0.85
690	1	Beheira-W	0.05	-3.15	-2.81	-2.01	8.79	8.07	3.78	-15.03	-22.65	27.44	-13.06	11.43
692	1	Qualyubia	3.89	-36.54	-6.02	-9.98	-2.92	2.43	17.70	-3.97	25.53	7.14	1.81	14.82
692	2	Qualyubia	2.46	-12.69	-5.98	-9.50	-0.74	1.43	13.58	-11.22	9.27	18.10	5.39	-6.57
692	3	Qualyubia	9.47	7.84	-1.07	-34.24	2.00	1.49	4.61	-21.10	13.56	7.41	6.10	-0.82
692	3	Qualyubia	6.97	-8.51	2.50	-26.07	7.69	0.72	6.33	-11.05	2.34	7.88	5.65	-0.63
692	3	Qualyubia	4.18	-2.37	2.91	-26.59	6.78	7.57	5.71	-16.23	-2.33	10.58	5.42	-8.04
694	2	Qualyubia	1.35	-13.55	-8.05	-9.40	-3.33	2.02	17.82	-5.54	32.82	4.93	3.94	-11.89
696	2	Qualyubia	0.03	-4.69	-2.90	-19.30	10.48	6.26	7.78	-52.00	19.75	6.11	12.59	0.46
696	3	Qualyubia	3.57	13.83	-6.07	-28.35	-3.91	-12.20	2.22	-22.04	7.66	-5.09	29.12	10.27
696	3	Qualyubia	7.54	4.77	-4.47	-33.78	0.62	9.91	8.13	-48.65	16.93	-13.06	16.34	13.57
710	2	Beheira-O	-4.52	-6.27	-0.08	-2.61	6.58	-8.98	0.67	19.18	8.52	-0.82	-0.71	-5.00
710	3	Beheira-O	-0.04	-8.58	-1.32	2.54	1.69	6.29	-2.90	23.50	-30.56	11.42	-1.16	-8.46
710	1	Beheira-O	4.79	9.70	-8.21	23.81	-30.97	16.10	7.53	17.30	-38.82	-31.95	3.90	-11.83
712	3	Beheira-W	0.87	-6.86	-6.96	1.03	-5.70	3.24	-5.70	13.04	-7.61	17.50	1.48	-2.57
721	2	Beheira-O	-3.33	-9.97	-4.28	10.40	8.01	-0.51	23.06	30.96	-13.73	-5.96	-13.47	-16.90
721	3	Beheira-O	1.25	-13.03	-0.69	3.34	0.56	7.36	0.19	27.74	-32.05	6.12	-0.94	-8.42
724	3	Beheira-O	-2.19	-15.73	-4.01	9.27	-1.53	5.10	-0.63	19.71	-16.10	8.46	-2.74	0.10
724	2	Beheira-O	-13.06	-25.67	-1.68	4.02	23.40	-6.23	10.05	36.81	27.65	-11.05	-0.30	-27.39
724	1	Beheira-O	0.93	47.69	6.12	8.82	-3.31	3.31	-8.56	-51.21	-47.48	-25.37	-12.39	19.07
725	3	Beheira-O	-1.33	-18.26	-4.76	4.14	-0.44	0.83	-1.12	24.95	2.77	12.86	-2.07	-8.95
725	2	Beheira-O	-19.06	-34.90	0.22	5.42	29.15	-7.03	17.22	37.49	38.22	-8.35	-2.67	-31.59
725	1	Beheira-O	-2.88	17.24	-6.16	29.89	-32.17	18.99	7.88	12.87	-53.79	-29.45	-9.36	0.12
726	2	Beheira-O	-6.93	-6.51	4.45	-2.64	8.74	-6.84	1.58	18.20	6.48	-3.92	-2.81	-8.22
726	3	Beheira-O	-2.57	-17.03	-0.71	4.23	4.91	6.54	0.15	26.12	-30.24	20.48	-3.10	-10.06
727	3	Beheira-O	-0.76	-10.75	-3.80	2.53	0.26	7.12	-2.41	26.34	-26.81	17.89	-3.16	-6.46
727	1	Beheira-O	5.23	3.48	-7.47	-7.54	-15.21	17.49	-11.47	-70.86	95.70	-14.73	-6.83	3.44
728	2	Beheira-O	-0.86	-9.60	-0.72	2.79	17.88	1.23	1.41	29.54	0.26	-15.28	-2.78	-27.98
728	3	Beheira-O	-0.44	-15.22	2.21	0.34	2.01	5.40	-3.67	27.90	-29.22	7.47	-2.36	-1.13
728	1	Beheira-O	-5.14	14.52	5.46	-9.15	-5.34	-14.42	-14.15	-18.54	35.77	-11.54	-6.15	23.13
729	3	Beheira-O	1.62	-8.09	-2.63	0.82	-0.71	5.59	-2.59	26.61	-33.86	10.32	-1.01	0.42
729	2	Beheira-O	-2.98	-13.64	2.98	-4.08	15.09	-3.52	-8.38	12.55	11.78	0.94	0.73	-10.39
729	1	Beheira-O	4.42	1.65	-12.95	-11.92	-17.22	14.81	-14.28	-86.77	106.56	-12.23	17.90	-0.03
732	3	Beheira-O	0.53	-15.42	1.54	5.17	2.67	7.51	-1.79	27.26	-30.20	7.71	-3.43	-10.54
732	2	Beheira-O	-5.71	-8.52	4.14	-5.18	11.86	-6.30	3.21	17.22	0.60	-3.64	0.38	-10.03
732	1	Beheira-O	13.64	16.88	-0.64	16.83	-29.06	19.22	7.57	-28.71	-60.41	-17.47	2.95	2.61
733	1	Beheira-O	-4.35	20.03	5.47	-3.23	-2.14	-3.86	-9.83	-31.94	2.75	-7.45	-0.83	9.90
734	2	Beheira-O	-1.63	-12.44	3.30	6.44	8.99	-3.09	-3.53	14.57	-42.10	-3.39	14.92	-6.83
734	1	Beheira-O	13.21	15.48	1.11	-6.34	7.28	-9.32	-8.83	-6.93	-30.88	-8.11	-0.40	10.24
735	2	Beheira-O	2.18	0.59	0.96	0.64	1.58	-7.74	-7.47	12.92	-45.72	-2.62	22.50	-2.91
735	1	Beheira-O	3.21	45.16	1.06	8.07	-5.86	9.22	-9.02	-55.25	-47.57	-19.17	-11.57	21.86
736	3	Beheira-O	6.84	-9.50	-2.29	-11.74	5.39	0.48	3.62	10.70	11.28	-26.28	1.72	5.16
736	3	Beheira-O	8.71	-4.48	-3.09	-9.78	4.71	4.57	8.88	16.77	4.70	-41.93	5.42	-9.98
736	2	Beheira-O	4.90	2.92	4.33	-7.61	-1.23	1.79	-8.40	5.23	-33.18	4.74	4.45	1.76

Farm no.	Year*)	Site	N	P	S	K	Ca	Mg	B	Mo	Fe	Mn	Cu	Zn
736	1	Beheira-O	-4.58	-14.40	-8.85	1.68	3.28	4.22	4.17	2.51	-5.87	18.96	-2.99	10.57
737	2	Beheira-W	3.12	-1.82	0.97	-7.94	-1.71	3.65	-4.57	5.28	-28.95	6.34	8.51	-2.13
739	2	Beheira-W	-1.93	-2.47	4.67	-2.47	1.81	-2.55	-7.83	7.43	-30.40	3.24	12.88	-5.21
739	1	Beheira-O	-1.91	3.45	0.94	0.24	-2.62	-0.73	-3.73	-6.86	-5.29	-1.20	-5.53	11.74
740	2	Beheira-W	-8.02	-13.66	7.49	5.90	11.65	-2.87	-3.21	11.96	-43.94	0.99	15.99	-10.07
740	1	Beheira-W	-0.97	0.97	-6.37	0.66	8.68	4.07	-0.13	-7.43	-5.18	34.33	-12.32	-8.45
741	2	Beheira-W	-0.09	-8.26	2.72	4.14	9.03	-3.60	-4.44	17.62	-37.02	-0.71	8.54	-6.34
741	1	Beheira-W	-5.41	10.96	0.92	-3.79	-2.07	-0.48	-11.07	-25.82	3.73	1.43	5.20	7.56
743	3	Beheira-O	0.54	-9.64	-8.14	2.83	-2.70	8.23	-3.88	24.90	-29.80	15.00	1.19	0.06
743	1	Beheira-O	13.67	19.21	-0.15	20.13	-26.27	19.52	5.86	-6.10	-63.26	-19.98	-11.32	-3.28
744	2	Beheira-O	-0.25	-3.68	4.58	-8.69	0.02	4.66	-1.68	-0.73	-23.87	15.80	1.26	-4.54
745	1	Beheira-W	-9.06	19.51	4.17	-1.61	-0.64	-4.97	-6.64	-26.19	5.64	-6.56	-2.29	7.13
753	1	Sharqia-W	9.34	-0.59	-3.96	-9.81	4.20	5.75	7.42	-0.62	-14.89	-3.88	-4.19	-3.46
753	3	Sharqia-W	12.85	-4.09	-8.61	-11.42	5.31	7.49	1.25	-10.75	-5.11	-6.92	6.15	-2.71
753	2	Sharqia-W	1.40	3.02	-6.35	-8.13	-7.83	1.41	1.40	-34.76	50.91	2.57	3.64	-6.46
754	3	Sharqia-W	5.42	-6.48	-7.47	-17.47	7.63	21.07	18.92	-2.00	-16.97	-13.30	2.14	-14.38
754	1	Sharqia-W	14.20	6.42	-7.99	-11.60	9.32	17.90	15.74	-39.95	-16.55	-5.72	-7.89	-4.02
754	2	Sharqia-W	5.83	8.94	-6.31	-8.22	-10.30	6.08	-1.40	-29.84	37.35	1.10	0.07	-8.53
755	3	Sharqia-W	-0.43	-16.77	2.97	-14.27	16.20	19.89	17.59	-10.33	-3.06	-15.12	-3.48	-18.13
755	2	Sharqia-W	1.11	15.09	-26.35	-45.23	-17.88	-4.79	-6.46	-30.03	167.66	1.38	1.52	3.25
755	1	Sharqia-W	13.26	-4.82	1.94	-7.98	5.08	9.31	1.42	-8.50	-9.73	-21.06	-8.13	0.95
756	3	Sharqia-W	2.13	-5.48	4.49	-9.09	9.14	13.59	13.22	-5.83	-31.46	1.76	-8.81	-13.04
756	1	Sharqia-W	11.02	7.25	1.46	-12.73	1.94	7.84	3.21	-11.12	-15.52	-8.35	-12.32	3.07
756	2	Sharqia-W	-1.30	13.04	-22.76	-35.12	-17.18	-2.67	-4.22	-38.06	150.89	2.48	0.96	1.23
757	2	Sharqia-W	1.15	22.41	-12.91	-25.55	-9.82	-1.12	-4.28	-28.29	59.52	-7.89	2.80	9.22
757	3	Sharqia-W	19.83	-1.35	-19.21	-11.28	0.19	7.53	-2.64	-3.27	35.70	-14.39	2.04	-10.46
757	1	Sharqia-W	13.35	12.66	-6.81	-10.39	6.10	13.36	9.30	0.23	-22.21	-28.61	-8.82	-9.07
758	3	Sharqia-W	4.98	-6.07	-4.39	-39.26	4.39	3.39	-0.62	9.64	-35.34	14.08	-10.00	61.10
758	2	Sharqia-W	3.85	15.28	-26.05	-41.04	-14.20	-1.54	-2.69	-17.92	129.08	-5.01	0.45	4.50
759	2	Sharqia-O	-7.13	-12.44	-9.07	-20.98	-15.86	4.77	-4.73	-28.21	163.09	9.03	-7.92	-17.70
759	1	Sharqia-O	9.74	3.47	-4.31	-14.06	0.84	1.68	0.31	-44.70	55.39	19.09	-10.47	-6.56
759	3	Sharqia-O	-7.96	-24.05	-14.35	2.46	36.62	7.38	34.26	-37.20	23.31	25.44	-3.69	-32.29
760	1	Sharqia-O	11.92	9.92	-2.76	-12.75	3.89	-5.12	-2.48	-30.03	14.94	7.51	-5.14	3.21
760	2	Sharqia-O	-4.94	-5.76	3.36	-3.43	0.61	5.24	6.57	-27.90	28.57	3.30	-3.63	-10.10
760	3	Sharqia-O	3.70	-7.03	7.49	-4.72	-7.90	0.80	19.50	-28.07	-43.47	40.71	1.32	-0.41
760	3	Sharqia-O	-3.99	-22.72	-5.39	3.70	16.10	9.32	9.98	1.74	3.57	12.17	2.10	-29.26
761	1	Sharqia-O	10.10	5.00	-2.30	-14.25	2.95	-1.27	-1.12	-29.66	4.10	-0.48	10.44	-1.17
761	3	Sharqia-O	1.83	3.26	-13.08	-20.64	-0.47	8.67	4.30	-13.27	38.15	18.10	-2.90	-8.13
761	2	Sharqia-O	2.74	15.32	-2.65	-15.58	-3.60	8.19	5.44	-49.66	9.39	1.97	3.63	2.57
762	1	Sharqia-O	6.87	4.36	-12.99	5.09	-6.85	11.53	6.62	2.88	3.86	4.07	-15.33	-11.99
762	2	Sharqia-O	3.41	15.09	-14.19	-30.22	-4.78	0.09	-2.18	-52.77	18.28	17.17	5.47	47.01
762	3	Sharqia-O	11.55	10.48	-15.36	-0.18	-5.68	9.19	5.19	-24.77	16.95	22.82	-2.57	-26.24
763	2	Sharqia-O	2.18	4.51	-19.97	-17.82	-13.60	1.38	2.85	-9.14	102.28	1.00	-7.47	-6.21
763	1	Sharqia-O	16.97	9.93	-3.34	-16.35	4.65	1.99	-2.90	-59.95	31.79	4.93	-2.51	1.04
764	3	Sharqia-O	-0.12	5.04	-13.22	-19.89	-4.83	3.90	1.37	1.14	3.66	12.96	18.47	-6.16
764	1	Sharqia-O	0.97	1.42	1.51	-13.67	0.71	1.13	-1.01	-7.83	8.25	31.36	-15.43	-0.35
764	2	Sharqia-O	-5.85	9.69	-11.36	-31.83	-11.36	-2.00	-4.49	-53.40	137.73	11.32	7.85	-9.66
765	1	Sharqia-O	24.14	19.06	-4.26	-30.51	6.35	8.18	-1.49	-27.63	-5.13	1.51	-6.85	-2.25
766	2	Sharqia-O	-0.64	1.35	5.09	-10.50	-3.57	13.53	3.77	-37.76	20.15	1.70	-3.62	-8.17
767	2	Sharqia-O	2.56	0.81	3.64	-11.74	-4.42	12.59	2.69	-34.92	28.77	3.66	-2.89	-14.21
768	1	Sharqia-O	19.48	-19.58	-9.43	-4.65	7.74	0.61	10.55	17.82	7.31	9.30	-11.76	-15.49
768	2	Sharqia-O	-26.84	-22.40	-17.67	-39.17	-26.60	-2.24	-12.68	-99.70	361.72	23.89	-6.18	-18.39
769	1	Sharqia-O	-6.34	1.62	12.84	-5.31	11.87	-4.37	4.43	-20.08	24.40	10.59	-24.73	-8.22
769	2	Sharqia-O	-0.25	3.15	-0.11	-13.23	-5.53	8.70	-1.58	-33.63	21.63	1.69	7.12	-4.11
770	1	Sharqia-O	9.13	10.89	-8.84	-8.95	0.44	4.91	-1.69	-1.62	-3.29	23.33	-7.17	-17.20
770	2	Sharqia-O	-1.49	0.54	2.91	-13.46	-4.69	6.95	0.69	-40.60	28.77	2.09	7.01	-4.76
770	3	Sharqia-O	9.92	36.88	-18.95	-65.07	-27.17	-22.08	-22.01	11.08	115.08	25.31	10.19	10.48
771	2	Sharqia-O	-2.82	6.74	-7.01	-12.26	-7.33	0.03	-0.41	-42.87	51.01	1.28	9.49	0.35

Farm no.	Year*)	Site	N	P	S	K	Ca	Mg	B	Mo	Fe	Mn	Cu	Zn
771	1	Sharqia-O	6.34	13.15	-3.27	-7.72	2.65	6.14	-5.31	-5.55	-7.34	25.83	-10.72	-20.43
772	1	Sharqia-O	3.16	17.06	-1.97	-11.30	-1.05	1.59	-5.10	-9.60	-6.28	24.98	-8.53	-8.48
772	3	Sharqia-O	9.99	8.17	-13.74	-20.66	-0.58	6.02	4.29	-29.26	9.78	13.55	7.61	1.89
772	2	Sharqia-O	-2.16	1.00	2.48	-9.60	-6.21	7.02	3.58	-38.18	29.27	1.43	1.20	-2.70
773	1	Sharqia-O	8.06	14.60	-7.22	-9.10	-1.45	2.92	-1.34	-4.97	-6.85	22.02	-8.10	-11.63
773	3	Sharqia-O	8.53	4.70	-10.73	-23.60	-6.03	-2.03	0.00	-5.16	40.96	14.82	-0.79	-1.24
774	1	Sharqia-W	0.78	-0.03	-1.60	-7.42	-0.34	0.64	7.43	-41.68	11.09	-5.48	4.05	13.83
774	2	Sharqia-W	1.61	14.15	-8.91	-16.80	-11.48	3.29	0.51	-32.11	32.22	-0.92	8.20	2.83
775	3	Sharqia-W	11.74	-5.66	-15.89	-16.25	-0.93	3.74	5.71	17.31	9.42	-10.13	3.49	3.27
775	1	Sharqia-W	9.83	8.58	-13.91	-9.02	1.77	9.41	7.33	-4.09	-2.36	-6.41	-10.84	1.76
775	2	Sharqia-W	-0.10	9.63	-2.85	-8.24	-10.09	5.46	1.82	-32.83	19.54	-1.76	4.11	-0.93
776	3	Sharqia-W	-14.26	-12.17	-5.42	-7.51	13.53	10.87	13.08	3.30	31.14	6.06	-7.95	-23.63
776	2	Sharqia-W	3.69	15.29	-4.95	-11.40	-9.85	6.88	0.83	-40.07	13.86	1.34	5.57	-0.26
776	1	Sharqia-W	13.70	11.71	-1.07	-13.14	4.68	5.98	0.92	0.87	-17.36	-21.72	-9.67	-1.23
777	1	Sharqia-W	-6.70	17.66	2.53	-3.31	-4.02	-8.33	-12.25	-35.04	5.57	-9.59	0.77	30.96
777	2	Sharqia-W	2.19	10.38	-2.82	-15.78	-9.40	8.53	-0.72	-45.45	18.13	2.64	6.60	7.31
778	1	Qualyubia	-0.73	-11.37	-1.28	-23.55	5.67	3.21	7.76	-19.18	18.72	21.25	-4.51	12.09
784	2	Beheira-O	-4.59	-9.82	2.95	-6.83	11.40	-2.24	-2.63	22.04	3.57	-2.37	1.62	-13.37
784	3	Beheira-O	-1.39	-8.59	-5.95	-1.87	0.33	5.73	-3.04	24.31	-20.80	17.10	1.29	-4.55
785	3	Beheira-O	-1.29	-11.98	-1.44	2.65	1.11	5.45	-3.47	26.32	-28.07	10.07	0.30	-4.85
785	2	Beheira-O	-17.04	-17.88	-0.75	4.15	12.58	2.48	44.33	20.77	6.05	4.03	-14.00	-32.47
785	1	Beheira-O	-6.71	0.95	9.62	-11.50	-6.79	-11.86	6.16	16.59	21.15	-12.65	-15.54	13.92
786	2	Beheira-O	-5.61	-3.09	10.20	-13.52	13.80	-13.31	-12.76	3.65	16.55	5.49	3.21	-4.08
786	3	Beheira-O	1.74	-7.42	-6.42	1.43	-1.60	6.52	-0.19	24.62	-36.67	19.52	1.78	-6.78
786	1	Beheira-O	-1.36	5.70	3.10	-1.40	0.61	-3.04	-7.04	-9.13	-2.22	-2.69	-4.01	6.59
787	3	Beheira-O	0.89	-12.32	-2.40	4.20	-3.53	5.82	-1.73	22.52	-22.62	12.60	3.27	-10.41
787	2	Beheira-O	-23.30	-27.91	-0.55	5.32	19.87	-4.13	25.35	24.26	39.71	-3.26	-4.13	-27.98
788	2	Beheira-O	-0.47	-18.11	2.73	-12.36	14.31	-11.02	-5.55	21.89	20.47	3.93	6.02	-8.05
788	3	Beheira-O	-0.09	-17.72	-1.19	7.79	2.61	7.19	-1.34	28.15	-40.12	14.65	1.89	-9.81
788	1	Beheira-O	2.27	18.62	-7.48	19.78	-34.93	22.45	6.60	-18.66	-43.21	-12.10	6.84	-3.23
789	3	Beheira-O	-0.69	-8.13	-2.29	1.84	-2.56	9.64	-3.02	16.70	-20.86	13.39	0.06	-10.47
789	2	Beheira-O	-7.06	-12.15	-1.15	2.92	10.37	0.69	25.00	20.78	-2.94	-1.69	-7.03	-24.87
790	2	Beheira-O	-2.46	-8.50	3.59	-9.62	12.16	-7.20	-2.58	14.89	19.09	1.06	1.07	-12.60
790	3	Beheira-O	0.67	-13.09	-2.86	2.86	-2.64	4.64	-0.66	24.22	-18.96	7.92	2.08	-5.71
6771	1	Faiyum	-3.99	-23.99	10.40	-6.57	-3.08	-8.40	25.50	-10.43	33.35	42.83	-18.70	-11.45
6771	3	Faiyum	-16.11	-69.24	-5.40	-16.84	-22.18	-23.75	13.80	-9.98	66.17	68.26	14.26	70.72
6772	3	Faiyum	-7.32	-44.06	7.31	-7.41	-1.89	-2.93	36.05	-20.33	51.11	20.35	-5.00	-6.46
7821	3	Dakah.-Da.	-10.85	18.19	8.94	-25.91	2.18	0.99	-0.79	-28.43	36.03	-24.89	2.74	0.99
7822	3	Dakah.-Da.	-5.85	17.09	2.83	-26.19	0.30	-0.02	1.57	-28.63	34.94	-29.30	10.99	1.88

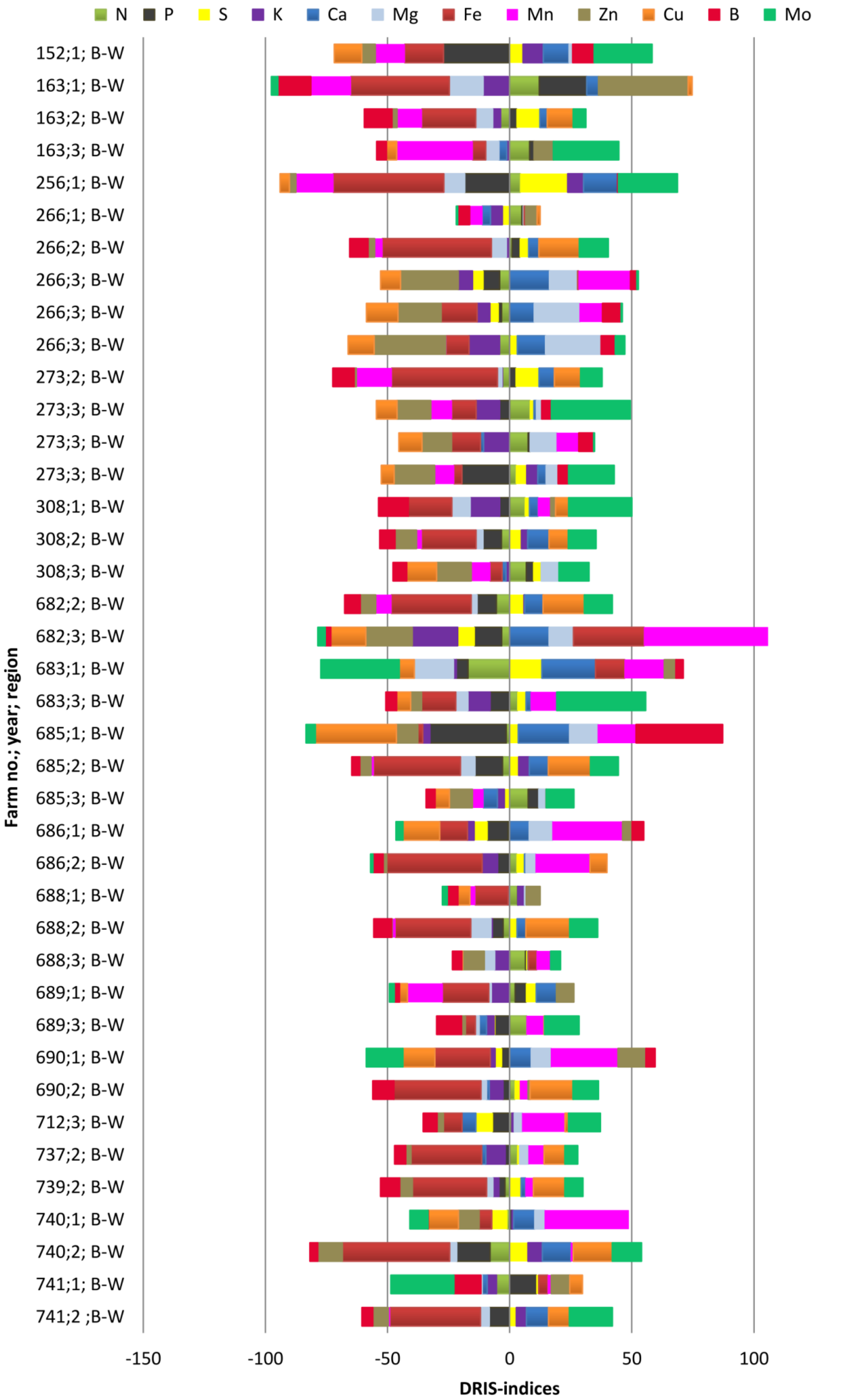


Fig. 8.9: DRIS-indices according to Walworth and Sumner (1987) for element-concentrations in young, fully developed main stem leaf blades of organically grown cotton (*Gossypium barbadense*), sampled in 2008-2010.

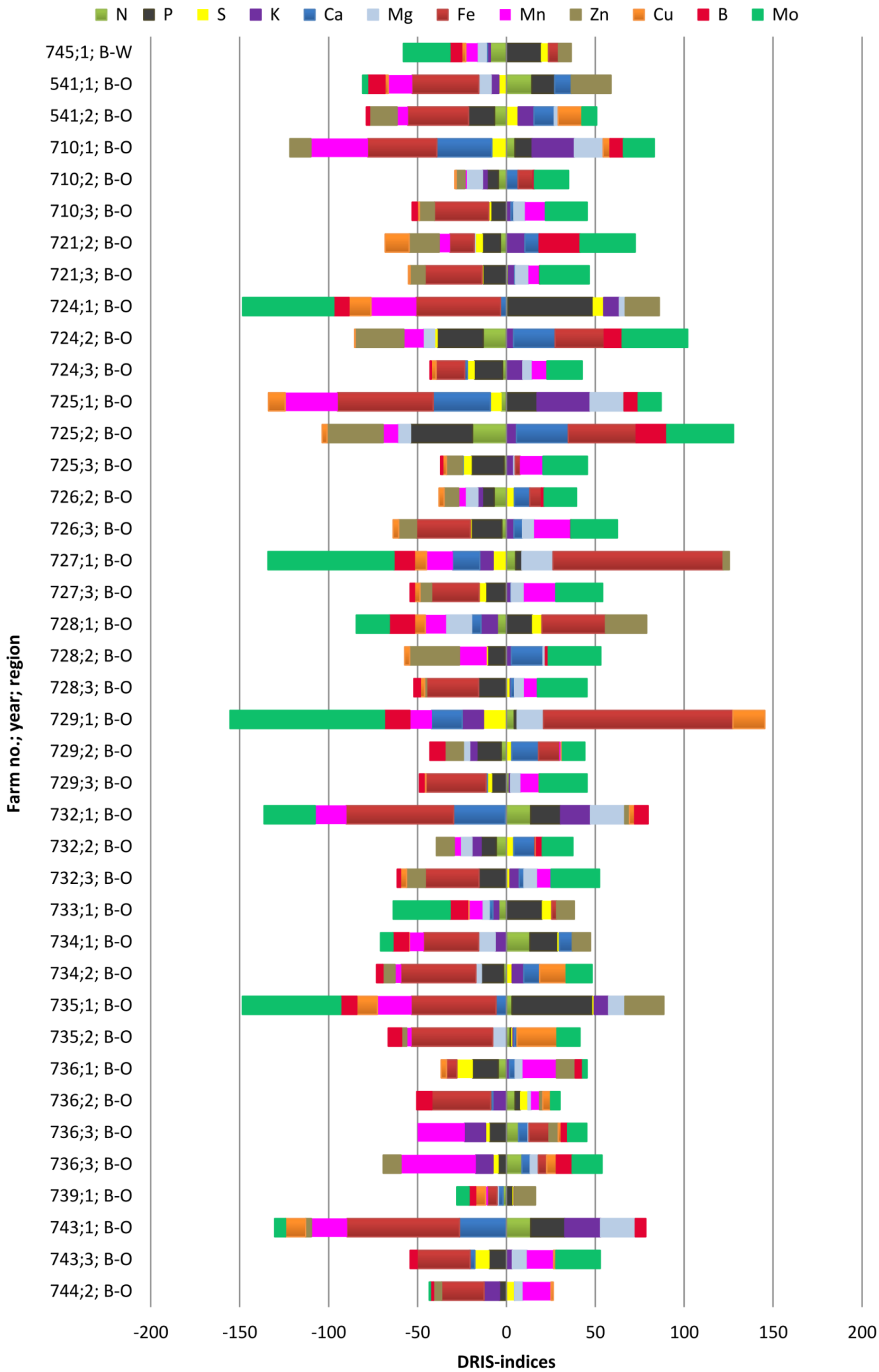


Fig. 8.9 continued; Year: 1=2008, 2=2009, 3=2010; region: B-W=Beheira-west, B-O=Beheira-east, S-W=Sharqia-west, S-O=Sharqia-east, Dah=Dakahlia/Damietta, Qal=Qalyubia, Fai=Faiyum.

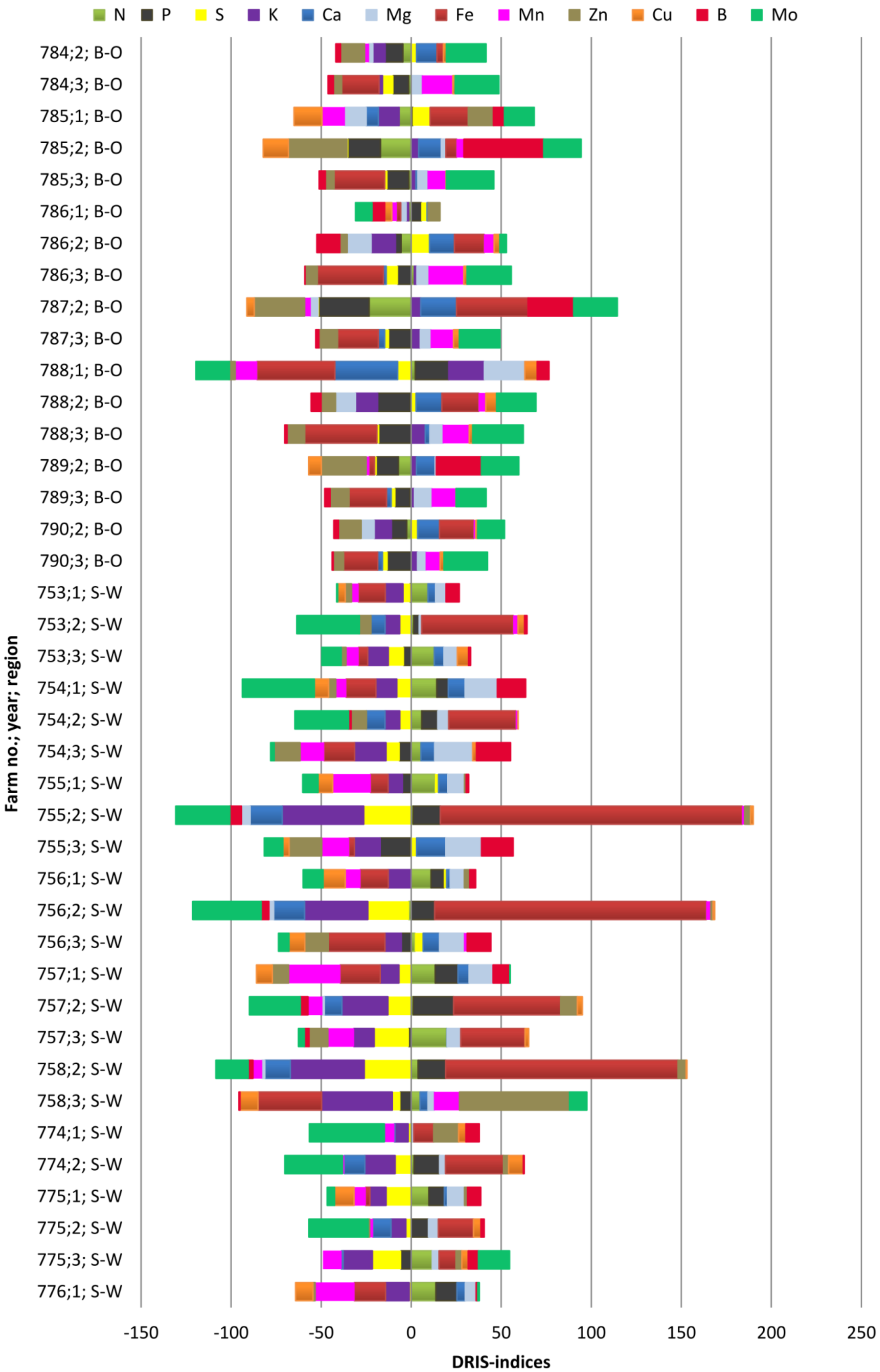


Fig. 8.9 continued

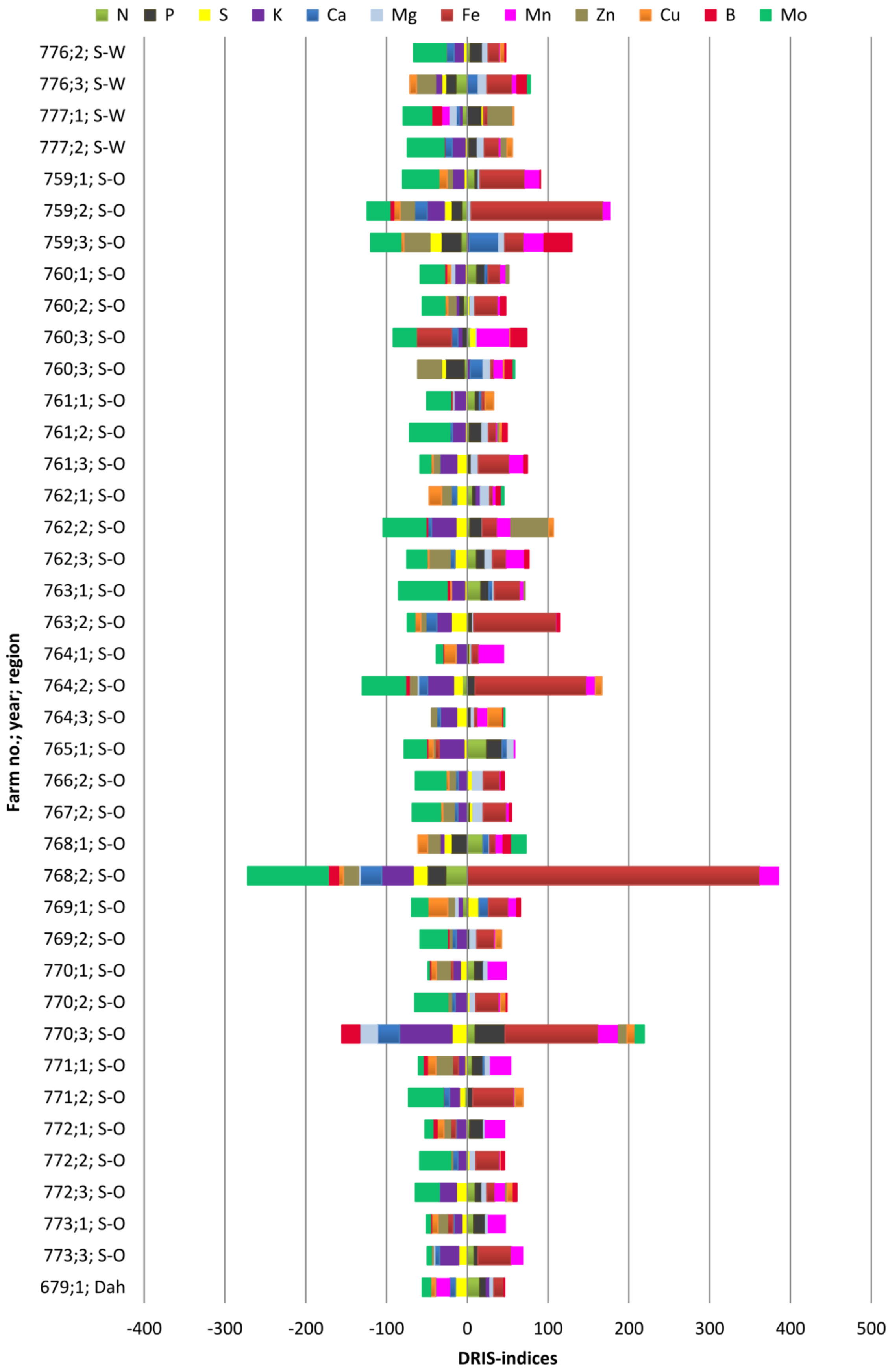


Fig 8.9 continued

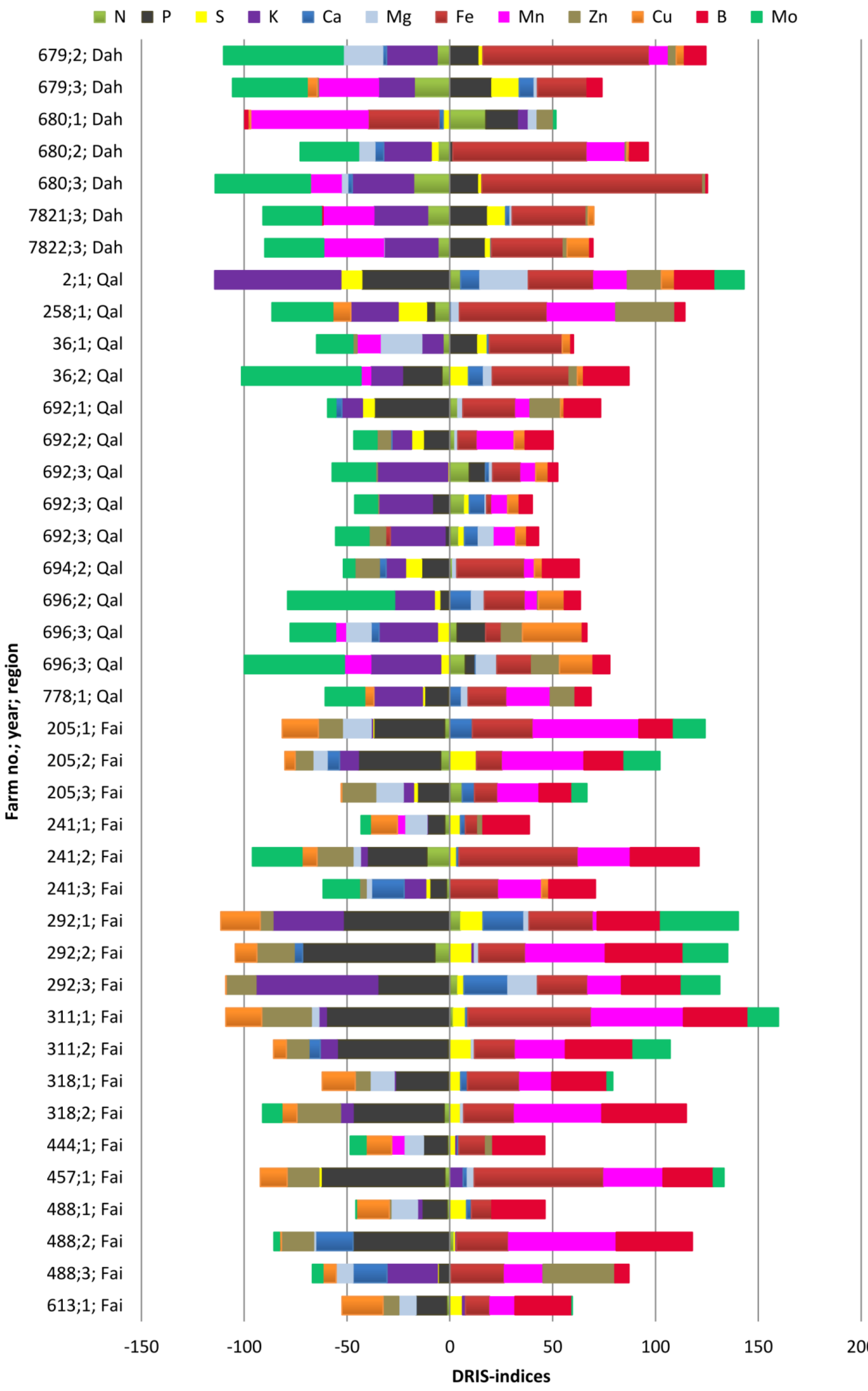


Fig. 8.9 continued

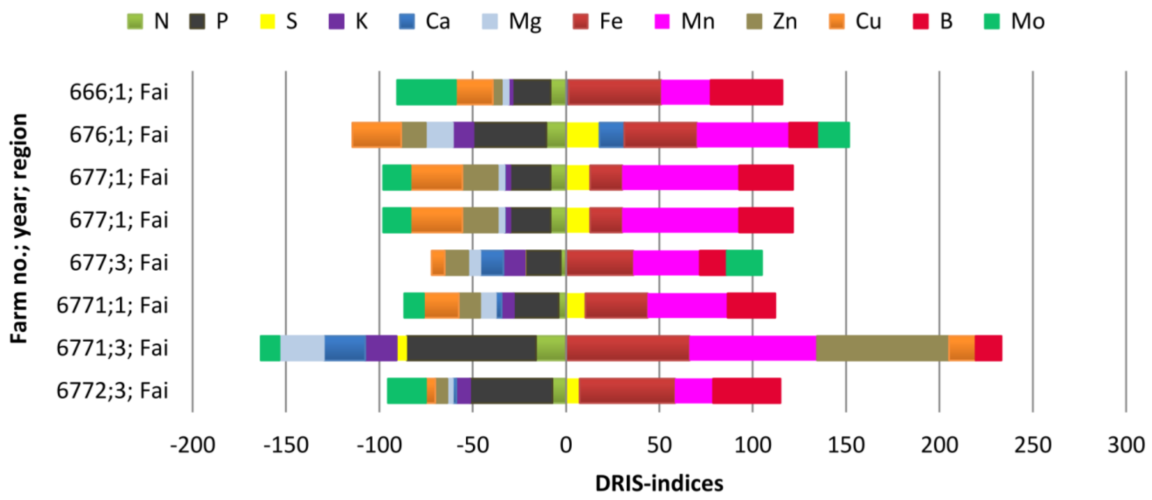


Fig. 8.9 continued

Tab. 8.30: **Mean DRIS-indices for the 3 different years of sampling for element concentration in organically grown cotton (*Gossypium barbadense*).**

8.30.1 DRIS-indices diagnosing deficiency

Element	Year	N	Mean	Standard Deviation	Minimum	Maximum
N	2008	74	1.9	3.28	0.0	17.0
	2009	68	3.7	5.45	0.0	26.8
	2010	66	2.0	4.26	0.0	17.6
	Total	208	2.5	4.45	0.0	26.8
P	2008	74	8.9	15.0	0.0	60.1
	2009	68	9.7	14.2	0.0	64.3
	2010	66	9.2	11.5	0.0	69.2
	Total	208	9.2	13.6	0.0	69.2
S	2008	74	3.0	4.15	0.0	14.7
	2009	68	3.4	6.45	0.0	26.3
	2010	66	4.1	5.07	0.0	19.2
	Total	208	3.5	5.28	0.0	26.3
K	2008	74	7.3	9.59	0.0	61.3
	2009	68	9.8	10.9	0.0	45.2
	2010	66	11.7	13.9	0.0	65.1
	Total	208	9.5	11.6	0.0	65.1
Ca	2008	74	3.3	8.05	0.0	34.9
	2009	68	4.0	5.91	0.0	26.6
	2010	66	2.5	5.27	0.0	27.2
	Total	208	3.3	6.58	0.0	34.9
Mg	2008	74	3.1	4.74	0.0	16.0
	2009	68	3.0	4.33	0.0	20.0
	2010	66	1.7	4.64	0.0	23.7
	Total	208	2.6	4.60	0.0	23.7
Fe	2008	74	10.7	16.9	0.0	63.3
	2009	68	9.4	15.8	0.0	45.7
	2010	66	10.1	13.4	0.0	43.5
	Total	208	10.1	15.4	0.0	63.3
Mn	2008	74	6.9	10.3	0.0	57.3
	2009	68	2.0	3.64	0.0	15.3
	2010	66	4.6	9.41	0.0	41.9
	Total	208	4.6	8.59	0.0	57.3
Zn	2008	74	4.1	6.15	0.0	24.1
	2009	68	8.3	8.59	0.0	32.5
	2010	66	8.2	8.35	0.0	32.3

Element	Year	N	Mean	Standard Deviation	Minimum	Maximum
	Total	208	6.8	7.94	0.0	32.5
Cu	2008	74	9.0	7.87	0.0	33.2
	2009	68	1.7	3.32	0.0	14.0
	2010	66	2.8	3.82	0.0	14.3
	Total	208	4.6	6.39	0.0	33.2
B	2008	74	2.5	4.26	0.0	14.3
	2009	68	2.7	3.52	0.0	12.8
	2010	66	1.5	3.22	0.0	22.0
	Total	208	2.3	3.73	0.0	22.0
Mo	2008	74	14.9	19.3	0.0	86.8
	2009	68	16.0	21.3	0.0	99.7
	2010	66	7.3	12.5	0.0	48.6
	Total	208	12.9	18.5	0.0	99.7

8.30.2 DRIS-indices diagnosing excess supply

Element	Year	N	Mean	Standard Deviation	Minimum	Maximum
N	2008	74	1.87	3.28	0.0	17.0
	2009	68	3.70	5.45	0.0	26.8
	2010	66	2.00	4.26	0.0	17.6
	Total	208	2.51	4.45	0.0	26.8
P	2008	74	8.86	15.0	0.0	60.1
	2009	68	9.68	14.2	0.0	64.3
	2010	66	9.20	11.5	0.0	69.2
	Total	208	9.24	13.6	0.0	69.2
S	2008	74	3.00	4.15	0.0	14.7
	2009	68	3.41	6.45	0.0	26.3
	2010	66	4.05	5.07	0.0	19.2
	Total	208	3.47	5.28	0.0	26.3
K	2008	74	7.28	9.59	0.0	61.3
	2009	68	9.84	10.9	0.0	45.2
	2010	66	11.7	13.9	0.0	65.1
	Total	208	9.53	11.6	0.0	65.1
Ca	2008	74	3.34	8.05	0.0	34.9
	2009	68	4.03	5.91	0.0	26.6
	2010	66	2.50	5.27	0.0	27.2
	Total	208	3.30	6.58	0.0	34.9
Mg	2008	74	3.05	4.74	0.0	16.0
	2009	68	3.04	4.33	0.0	20.0
	2010	66	1.71	4.64	0.0	23.7
	Total	208	2.62	4.60	0.0	23.7
Fe	2008	74	10.7	16.9	0.0	63.3
	2009	68	9.4	15.8	0.0	45.7
	2010	66	10.1	13.4	0.0	43.5
	Total	208	10.1	15.4	0.0	63.3
Mn	2008	74	6.9	10.3	0.0	57.3
	2009	68	1.98	3.64	0.0	15.3
	2010	66	4.62	9.41	0.0	41.9
	Total	208	4.58	8.59	0.0	57.3
Zn	2008	74	4.14	6.15	0.0	24.1
	2009	68	8.32	8.59	0.0	32.5
	2010	66	8.17	8.35	0.0	32.3
	Total	208	6.79	7.94	0.0	32.5
Cu	2008	74	9.03	7.87	0.0	33.2
	2009	68	1.72	3.32	0.0	14.0
	2010	66	2.75	3.82	0.0	14.3
	Total	208	4.65	6.39	0.0	33.2
B	2008	74	2.54	4.26	0.0	14.3
	2009	68	2.71	3.52	0.0	12.8
	2010	66	1.49	3.22	0.0	22.0
	Total	208	2.26	3.73	0.0	22.0
Mo	2008	74	14.9	19.3	0.0	86.8
	2009	68	16.0	21.3	0.0	99.7

Element	Year	N	Mean	Standard Deviation	Minimum	Maximum
	2010	66	7.3	12.5	0.0	48.6
	Total	208	12.9	18.5	0.0	99.7

Tab. 8.31: Mean DRIS-indices for 7 different Egyptian regions for element concentrations in organically grown cotton (*Gossypium barbadense*).

8.31.1 DRIS-indices diagnosing deficiency

Element	Region	N	Mean	Standard Deviation	Minimum	Maximum
N	Beheira-W	41	1.97	3.35	0.0	17.0
	Beheira-O	56	2.92	4.88	0.0	23.3
	Sharqia-W	27	0.84	2.98	0.0	14.3
	Sharqia-O	35	2.02	4.92	0.0	26.8
	Dakahlia-Da.	8	7.94	6.87	0.0	17.6
	Qalyubia	14	1.10	2.23	0.0	7.39
	Faiyum	27	3.94	4.26	0.0	16.1
	Total	208	2.51	4.45	0.0	26.8
P	Beheira-W	41	5.49	7.40	0.0	31.3
	Beheira-O	56	8.62	8.02	0.0	34.9
	Sharqia-W	27	2.35	4.22	0.0	16.8
	Sharqia-O	35	3.26	7.37	0.0	24.1
	Dakahlia-Da.	8	0.00	0.00	0.0	0.0
	Qalyubia	14	11.1	13.5	0.0	42.6
	Faiyum	27	32.6	19.0	5.5	69.2
	Total	208	9.24	13.6	0.0	69.2
S	Beheira-W	41	1.06	2.10	0.0	6.97
	Beheira-O	56	2.13	3.00	0.0	12.9
	Sharqia-W	27	8.02	7.95	0.0	26.3
	Sharqia-O	35	7.07	6.35	0.0	20.0
	Dakahlia-Da.	8	2.69	5.10	0.0	14.7
	Qalyubia	14	4.30	4.38	0.0	14.0
	Faiyum	27	0.48	1.16	0.0	5.40
	Total	208	3.47	5.28	0.0	26.3
K	Beheira-W	41	3.96	4.44	0.0	18.6
	Beheira-O	56	2.71	4.21	0.0	13.5
	Sharqia-W	27	15.8	11.3	3.3	45.2
	Sharqia-O	35	15.2	12.8	0.0	65.1
	Dakahlia-Da.	8	18.3	11.9	0.0	29.8
	Qalyubia	14	23.6	13.9	9.4	61.3
	Faiyum	27	8.5	12.9	0.0	59.2
	Total	208	9.5	11.6	0.0	65.1
Ca	Beheira-W	41	0.73	1.48	0.0	5.74
	Beheira-O	56	4.09	9.06	0.0	34.9
	Sharqia-W	27	4.57	6.05	0.0	17.9
	Sharqia-O	35	4.84	6.88	0.0	27.2
	Dakahlia-Da.	8	2.18	2.40	0.0	6.81
	Qalyubia	14	0.78	1.44	0.0	3.91
	Faiyum	27	3.94	6.74	0.0	22.2
	Total	208	3.30	6.58	0.0	34.9
Mg	Beheira-W	41	2.78	3.87	0.0	16.0
	Beheira-O	56	2.47	3.99	0.0	14.4
	Sharqia-W	27	0.68	1.87	0.0	8.33
	Sharqia-O	35	1.12	3.85	0.0	22.1
	Dakahlia-Da.	8	3.76	6.83	0.0	19.2
	Qalyubia	14	2.30	6.05	0.0	20.0
	Faiyum	27	6.42	5.95	0.0	23.7
	Total	208	2.62	4.60	0.0	23.7
Fe	Beheira-W	41	17.7	15.4	0.0	45.2
	Beheira-O	56	19.3	19.1	0.0	63.3
	Sharqia-W	27	7.06	10.5	0.0	35.3

Element	Region	N	Mean	Standard Deviation	Minimum	Maximum
	Sharqia-O	35	2.07	7.51	0.0	43.5
	Dakahlia-Da.	8	4.28	12.1	0.0	34.3
	Qalyubia	14	0.17	0.62	0.0	2.33
	Faiyum	27	0.00	0.00	0.0	0.00
	Total	208	10.1	15.4	0.0	63.3
Mn	Beheira-W	41	4.2	6.65	0.0	31.1
	Beheira-O	56	6.7	9.73	0.0	41.9
	Sharqia-W	27	6.9	7.80	0.0	28.6
	Sharqia-O	35	0.0	0.08	0.0	0.48
	Dakahlia-Da.	8	21.7	18.5	0.0	57.3
	Qalyubia	14	2.46	4.52	0.0	13.1
	Faiyum	27	0.37	1.35	0.0	6.13
	Total	208	4.58	8.59	0.0	57.3
Zn	Beheira-W	41	6.08	7.23	0.0	29.2
	Beheira-O	56	7.60	8.79	0.0	32.5
	Sharqia-W	27	4.31	6.52	0.0	23.6
	Sharqia-O	35	8.67	8.88	0.0	32.3
	Dakahlia-Da.	8	0.17	0.31	0.0	0.67
	Qalyubia	14	2.14	3.82	0.0	11.9
	Faiyum	27	10.6	7.18	0.0	24.1
	Total	208	6.79	7.94	0.0	32.5
Cu	Beheira-W	41	4.95	6.78	0.0	33.2
	Beheira-O	56	2.80	4.20	0.0	15.5
	Sharqia-W	27	3.41	4.49	0.0	12.3
	Sharqia-O	35	4.81	5.76	0.0	24.7
	Dakahlia-Da.	8	1.50	2.38	0.0	5.66
	Qalyubia	14	0.95	2.56	0.0	8.79
	Faiyum	27	11.9	8.62	0.0	27.8
	Total	208	4.65	6.39	0.0	33.2
B	Beheira-W	41	4.35	3.93	0.0	13.5
	Beheira-O	56	3.28	4.12	0.0	14.3
	Sharqia-W	27	1.31	2.77	0.0	12.3
	Sharqia-O	35	2.01	4.31	0.0	22.0
	Dakahlia-Da.	8	0.28	0.55	0.0	1.47
	Qalyubia	14	0.00	0.00	0.0	0.00
	Faiyum	27	0.00	0.00	0.0	0.00
	Total	208	2.26	3.73	0.0	22.0
Mo	Beheira-W	41	3.04	7.64	0.0	32.1
	Beheira-O	56	7.04	18.2	0.0	86.8
	Sharqia-W	27	18.6	16.5	0.0	45.4
	Sharqia-O	35	26.5	22.0	0.0	99.7
	Dakahlia-Da.	8	29.5	18.5	0.0	58.2
	Qalyubia	14	22.6	18.3	0.0	58.1
	Faiyum	27	6.38	8.81	0.0	31.4
	Total	208	12.9	18.5	0.0	99.7

8.31.2 DRIS-indices diagnosing excess supply

Element	Region	N	Mean	Standard Deviation	Minimum	Maximum
N	Beheira-W	41	1.97	3.35	0.0	17.0
	Beheira-O	56	2.92	4.88	0.0	23.3
	Sharqia-W	27	0.84	2.98	0.0	14.3
	Sharqia-O	35	2.02	4.92	0.0	26.8
	Dakahlia-Da.	8	7.94	6.87	0.0	17.6
	Qalyubia	14	1.10	2.23	0.0	7.4
	Faiyum	27	3.94	4.26	0.0	16.1
	Total	208	2.51	4.45	0.0	26.8
P	Beheira-W	41	5.49	7.40	0.0	31.3
	Beheira-O	56	8.62	8.02	0.0	34.9
	Sharqia-W	27	2.35	4.22	0.0	16.8

	Sharqia-O	35	3.26	7.37	0.0	24.1
	Dakahlia-Da.	8	0.00	0.00	0.0	0.0
	Qalyubia	14	11.1	13.5	0.0	42.6
	Faiyum	27	32.6	19.0	5.5	69.2
	Total	208	9.2	13.6	0.0	69.2
S	Beheira-W	41	1.06	2.10	0.0	7.0
	Beheira-O	56	2.13	3.00	0.0	12.9
	Sharqia-W	27	8.02	7.95	0.0	26.3
	Sharqia-O	35	7.07	6.35	0.0	20.0
	Dakahlia-Da.	8	2.69	5.10	0.0	14.7
	Qalyubia	14	4.30	4.38	0.0	14.0
	Faiyum	27	0.48	1.16	0.0	5.4
	Total	208	3.47	5.28	0.0	26.3
K	Beheira-W	41	3.96	4.44	0.0	18.6
	Beheira-O	56	2.71	4.21	0.0	13.5
	Sharqia-W	27	15.8	11.3	3.3	45.2
	Sharqia-O	35	15.2	12.8	0.0	65.1
	Dakahlia-Da.	8	18.3	11.9	0.0	29.8
	Qalyubia	14	23.6	13.9	9.4	61.3
	Faiyum	27	8.48	12.9	0.0	59.2
	Total	208	9.53	11.6	0.0	65.1
Ca	Beheira-W	41	0.73	1.48	0.0	5.7
	Beheira-O	56	4.09	9.06	0.0	34.9
	Sharqia-W	27	4.57	6.05	0.0	17.9
	Sharqia-O	35	4.84	6.88	0.0	27.2
	Dakahlia-Da.	8	2.18	2.40	0.0	6.8
	Qalyubia	14	0.78	1.44	0.0	3.9
	Faiyum	27	3.94	6.74	0.0	22.2
	Total	208	3.30	6.58	0.0	34.9
Mg	Beheira-W	41	2.78	3.87	0.0	16.0
	Beheira-O	56	2.47	3.99	0.0	14.4
	Sharqia-W	27	0.68	1.87	0.0	8.3
	Sharqia-O	35	1.12	3.85	0.0	22.1
	Dakahlia-Da.	8	3.76	6.83	0.0	19.2
	Qalyubia	14	2.30	6.05	0.0	20.0
	Faiyum	27	6.42	5.95	0.0	23.7
	Total	208	2.62	4.60	0.0	23.7
Fe	Beheira-W	41	17.7	15.4	0.0	45.2
	Beheira-O	56	19.3	19.1	0.0	63.3
	Sharqia-W	27	7.06	10.47	0.0	35.3
	Sharqia-O	35	2.07	7.51	0.0	43.5
	Dakahlia-Da.	8	4.28	12.12	0.0	34.3
	Qalyubia	14	0.17	0.62	0.0	2.3
	Faiyum	27	0.00	0.00	0.0	0.0
	Total	208	10.1	15.4	0.0	63.3
Mn	Beheira-W	41	4.18	6.65	0.0	31.1
	Beheira-O	56	6.71	9.73	0.0	41.9
	Sharqia-W	27	6.90	7.80	0.0	28.6
	Sharqia-O	35	0.01	0.08	0.0	0.5
	Dakahlia-Da.	8	21.7	18.5	0.0	57.3
	Qalyubia	14	2.46	4.52	0.0	13.1
	Faiyum	27	0.37	1.35	0.0	6.1
	Total	208	4.58	8.59	0.0	57.3
Zn	Beheira-W	41	6.08	7.23	0.0	29.2
	Beheira-O	56	7.60	8.79	0.0	32.5
	Sharqia-W	27	4.31	6.52	0.0	23.6
	Sharqia-O	35	8.67	8.88	0.0	32.3
	Dakahlia-Da.	8	0.17	0.31	0.0	0.7
	Qalyubia	14	2.14	3.82	0.0	11.9
	Faiyum	27	10.6	7.18	0.0	24.1
	Total	208	6.79	7.94	0.0	32.5

Cu	Beheira-W	41	4.95	6.78	0.0	33.2
	Beheira-O	56	2.80	4.20	0.0	15.5
	Sharqia-W	27	3.41	4.49	0.0	12.3
	Sharqia-O	35	4.81	5.76	0.0	24.7
	Dakahlia-Da.	8	1.50	2.38	0.0	5.7
	Qalyubia	14	0.95	2.56	0.0	8.8
	Faiyum	27	11.9	8.62	0.0	27.8
	Total	208	4.65	6.39	0.0	33.2
B	Beheira-W	41	4.35	3.93	0.0	13.5
	Beheira-O	56	3.28	4.12	0.0	14.3
	Sharqia-W	27	1.31	2.77	0.0	12.3
	Sharqia-O	35	2.01	4.31	0.0	22.0
	Dakahlia-Da.	8	0.28	0.55	0.0	1.5
	Qalyubia	14	0.00	0.00	0.0	0.0
	Faiyum	27	0.00	0.00	0.0	0.0
	Total	208	2.26	3.73	0.0	22.0
Mo	Beheira-W	41	3.04	7.64	0.0	32.1
	Beheira-O	56	7.04	18.2	0.0	86.8
	Sharqia-W	27	18.6	16.5	0.0	45.4
	Sharqia-O	35	26.5	22.0	0.0	99.7
	Dakahlia-Da.	8	29.5	18.5	0.0	58.2
	Qalyubia	14	22.6	18.3	0.0	58.1
	Faiyum	27	6.38	8.81	0.0	31.4
	Total	208	12.9	18.5	0.0	99.7

Tab. 8.32: CND-indices for 207 samples of organically grown cotton (*Gossypium barbadense*) in Egypt.

Farm-no.	Region	Year	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo	Al	Rd
2	Qalyubia	1	-0.46	-2.65	-2.78	-4.25	0.23	1.21	1.00	0.48	0.44	-0.23	1.02	0.40	1.16	-0.17
36	Qalyubia	2	-0.68	0.56	-0.07	-1.30	-0.17	-2.11	1.32	-0.90	-0.49	-0.04	-0.13	-0.89	1.43	-0.54
36	Qalyubia	1	-1.39	-0.65	-3.10	-2.28	-0.25	-0.18	1.40	1.51	1.40	-1.11	-0.01	-1.42	1.40	-1.37
152	Beheira-W	1	-0.15	-1.67	0.63	0.60	0.82	0.02	-0.27	-0.68	-0.46	-0.92	0.81	1.19	0.13	0.20
163	Beheira-W	2	0.08	0.28	1.65	-0.22	0.43	-0.55	-0.41	-0.46	-0.05	0.95	-0.88	0.50	-0.27	0.38
163	Beheira-W	1	1.39	1.36	0.27	-0.61	0.68	-0.88	-0.79	-0.65	2.51	0.35	-0.78	0.20	-0.92	0.40
163	Beheira-W	3	0.82	0.14	-0.16	-0.09	-0.17	-0.54	0.14	-1.64	0.65	-0.33	-0.33	1.37	-0.15	-0.23
205	Faiyum	2	-0.90	-2.46	1.10	-1.14	-0.67	-1.02	0.62	1.92	-0.93	-0.71	1.34	0.72	0.84	-1.82
205	Faiyum	1	-1.06	-2.34	-1.23	-0.64	0.38	-1.72	1.05	2.20	-1.28	-1.74	0.97	0.55	1.17	-1.75
205	Faiyum	3	0.10	-1.34	-1.19	-0.87	0.20	-1.61	0.58	1.04	-1.54	-0.40	1.17	0.30	0.84	-0.30
241	Faiyum	1	-0.61	-0.79	0.27	-0.32	0.05	-1.28	0.47	-0.32	-0.01	-1.28	1.84	-0.25	0.85	-0.31
241	Faiyum	3	-0.59	-0.89	-1.27	-1.37	-1.49	-0.78	0.97	1.04	-0.63	-0.13	1.50	-1.01	1.13	0.84
241	Faiyum	2	-1.74	-2.10	-0.58	-0.83	-0.30	-0.90	1.71	1.12	-1.65	-1.03	2.06	-1.25	1.65	-0.91
256	Beheira-W	1	0.69	-0.93	3.13	0.71	1.28	-0.49	-0.90	-0.60	0.03	-0.07	0.39	1.38	-1.06	0.75
258	Qalyubia	1	-0.81	-1.49	0.47	-1.64	0.29	-0.06	1.34	-0.50	-0.07	-0.17	1.53	-2.21	1.30	0.48
266	Beheira-W	2	0.68	0.36	0.84	0.03	0.59	-0.38	-0.94	0.06	-0.02	1.43	-0.43	0.87	-0.99	0.86
266	Beheira-W	1	0.49	-0.04	-0.84	-0.61	-0.29	-0.12	0.32	-0.33	0.31	0.01	-0.60	0.03	0.36	-0.02
266	Beheira-W	3	-0.47	0.00	0.30	-1.09	0.99	1.91	-0.02	0.09	-1.95	-0.83	0.57	0.31	0.17	-0.30
266	Beheira-W	3	-0.38	-0.09	-0.69	-0.50	0.88	1.61	-0.21	0.73	-1.28	-1.00	0.76	0.13	0.02	-0.33
266	Beheira-W	3	-0.67	-0.62	-1.22	-0.76	1.15	0.84	0.27	1.26	-1.83	-0.84	0.11	0.06	0.52	-0.67
273	Beheira-W	3	0.19	-1.32	0.48	0.28	0.27	0.32	0.18	-0.46	-1.27	-0.50	0.35	0.98	0.28	-0.64
273	Beheira-W	3	0.74	0.06	-0.13	-0.96	0.00	0.98	-0.12	0.72	-0.92	-0.76	0.63	0.13	0.03	-0.45
273	Beheira-W	3	0.73	-0.32	0.08	-0.92	0.16	0.15	-0.06	-0.48	-1.07	-0.72	0.42	1.53	0.09	-0.39
273	Beheira-W	2	0.29	0.34	1.86	0.16	0.78	0.05	-0.89	-0.60	0.14	1.06	-0.51	0.73	-0.93	1.11
292	Faiyum	3	-0.47	-2.26	-0.76	-4.06	1.16	0.72	0.86	0.60	-1.40	-0.55	1.92	0.71	1.00	-1.39
292	Faiyum	1	-0.49	-2.99	0.25	-2.90	0.94	-0.34	1.03	-0.23	-0.93	-1.79	1.90	1.34	1.04	0.04
292	Faiyum	2	-1.36	-3.34	0.53	-0.43	-0.64	-0.40	0.87	1.75	-1.58	-1.16	2.33	0.75	0.97	-1.85
308	Beheira-W	2	0.06	-0.45	0.88	0.29	0.88	-0.18	-0.42	0.06	-0.58	0.74	-0.43	0.80	-0.48	0.03
308	Beheira-W	1	0.68	-0.31	0.15	-1.09	0.37	-0.70	-0.33	0.45	0.15	0.40	-1.06	1.36	-0.30	0.21
308	Beheira-W	3	0.67	0.20	0.45	-0.18	-0.05	0.63	0.15	-0.40	-1.06	-0.97	-0.56	0.75	0.30	-1.17
311	Faiyum	1	-0.92	-3.37	-0.57	-1.02	-0.47	-1.08	1.64	1.76	-2.11	-1.80	1.67	0.36	1.56	-0.98

Farm-no.	Region	Year	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo	Al	Rd
311	Faiyum	2	-0.70	-3.01	0.58	-1.14	-0.70	-0.39	0.82	1.16	-1.14	-0.86	2.15	0.67	0.96	-1.47
318	Faiyum	2	-0.90	-2.67	-0.20	-0.98	-0.32	-0.39	0.94	1.92	-1.79	-0.96	2.59	-0.59	1.08	-0.33
318	Faiyum	1	-0.76	-1.92	-0.17	-0.57	-0.09	-1.54	1.00	0.72	-0.93	-1.61	1.85	0.01	1.19	-0.61
444	Faiyum	1	-0.53	-1.04	-0.18	-0.27	-0.14	-1.22	0.70	-0.51	0.03	-1.26	1.95	-0.45	1.01	-0.22
457	Faiyum	1	-1.25	-3.40	-1.64	-0.25	-0.43	-0.55	1.72	1.13	-1.64	-1.56	1.21	-0.07	1.64	-0.25
488	Faiyum	2	-0.42	-2.78	-0.81	-0.47	-1.58	-0.68	0.96	2.28	-1.45	-0.49	2.25	-0.32	1.01	-0.50
488	Faiyum	3	-0.51	-0.69	-0.97	-2.33	-1.44	-1.18	1.03	0.92	1.85	-0.87	0.27	-0.34	1.09	-1.12
488	Faiyum	1	-0.57	-1.05	0.65	-0.52	0.02	-1.48	0.60	-0.10	-0.30	-1.48	2.03	-0.04	0.91	-0.82
541	Beheira-O	1	1.57	0.99	-0.38	-0.19	0.99	-0.38	-0.76	-0.54	1.75	0.05	-0.55	0.15	-0.85	0.49
541	Beheira-O	2	-0.02	-0.77	1.35	0.93	1.14	0.39	-0.67	-0.09	-0.90	1.24	0.11	0.67	-0.76	-0.26
613	Faiyum	1	-0.68	-1.24	0.25	-0.26	-0.23	-1.16	0.63	0.65	-0.86	-1.78	2.05	-0.07	0.88	-0.29
666	Faiyum	1	-1.61	-1.66	-1.08	-0.74	-0.29	-0.92	1.54	1.16	-0.81	-1.89	2.37	-1.54	1.47	0.20
676	Faiyum	1	-1.84	-2.50	1.29	-1.40	0.52	-1.68	1.26	2.07	-1.34	-2.20	0.88	0.57	1.49	-2.83
677	Faiyum	1	-1.34	-1.52	1.17	-0.57	-0.19	-0.65	0.79	2.74	-1.53	-2.14	2.01	-0.72	0.93	-1.67
677	Faiyum	3	-0.96	-1.59	-1.14	-1.50	-1.28	-1.17	1.25	1.62	-1.36	-1.00	0.76	0.68	1.46	-1.97
677	Faiyum	1	-1.34	-1.52	1.17	-0.57	-0.19	-0.65	0.79	2.74	-1.53	-2.14	2.01	-0.72	0.93	-1.67
679	Dakah.-Da.	3	-1.95	1.02	1.37	-1.66	0.42	-0.13	1.05	-1.73	-0.29	-0.63	0.47	-1.51	1.19	1.01
679	Dakah.-Da.	1	1.13	0.35	-2.83	0.11	-0.69	0.09	0.72	-1.16	-0.25	-0.67	-0.27	-0.56	0.79	1.23
679	Dakah.-Da.	2	-1.21	0.39	-0.88	-2.38	-0.51	-2.10	2.09	0.25	-0.23	-0.24	0.48	-2.23	2.00	-1.73
680	Dakah.-Da.	3	-2.25	0.36	-0.93	-2.73	-0.52	-0.82	2.44	-1.19	-0.39	-0.54	-0.41	-1.94	2.36	-0.02
680	Dakah.-Da.	1	1.81	1.16	-0.29	0.53	0.06	0.50	-0.67	-2.44	0.77	0.05	0.05	0.26	-0.55	2.01
680	Dakah.-Da.	2	-1.13	-0.34	-1.68	-2.36	-0.68	-1.27	1.86	0.80	-0.41	-0.40	0.37	-1.41	1.81	-1.63
682	Beheira-W	2	0.12	-0.40	1.19	0.17	0.84	-0.04	-0.67	-0.16	-0.31	1.46	-0.34	0.84	-0.71	0.09
682	Beheira-W	3	-1.06	-1.11	-2.10	-2.01	0.83	0.36	1.06	2.20	-1.77	-1.52	-0.63	-0.27	1.23	-0.14
683	Beheira-W	1	-1.82	-0.46	1.60	-0.31	1.52	-1.49	0.72	1.00	0.23	-0.64	0.31	-1.29	0.45	-1.25
683	Beheira-W	3	0.29	-0.58	0.41	-0.86	0.24	-0.49	-0.21	0.79	-0.36	-0.49	-0.36	1.70	-0.19	-0.74
685	Beheira-W	2	0.33	-0.62	0.80	0.51	0.84	-0.39	-0.74	0.18	-0.19	1.46	-0.05	0.83	-0.85	0.17
685	Beheira-W	1	-0.56	-1.93	0.02	-0.49	1.36	0.76	0.17	0.89	-0.79	-2.34	2.61	-0.18	0.33	-0.19
685	Beheira-W	3	0.68	0.25	-0.64	-0.39	-0.48	0.13	0.31	-0.26	-0.82	-0.58	-0.47	0.66	0.45	-1.02
686	Beheira-W	2	0.65	-0.24	0.68	-0.46	0.28	0.50	-0.84	1.59	0.03	0.69	-0.21	0.16	-0.76	0.42
686	Beheira-W	1	-0.11	-0.58	-1.00	-0.28	0.72	0.86	-0.10	1.79	0.32	-1.15	0.51	-0.03	-0.48	-0.43
688	Beheira-W	2	0.32	-0.21	0.64	0.04	0.49	-0.65	-0.64	0.13	0.12	1.48	-0.48	0.82	-0.67	0.27
688	Beheira-W	1	0.46	0.03	-0.04	0.26	0.05	0.05	-0.18	0.00	0.53	-0.39	-0.40	0.02	-0.14	0.43
688	Beheira-W	3	0.49	-0.14	-0.36	-0.81	-0.06	-0.66	0.40	0.37	-0.88	-0.22	-0.54	0.27	0.36	0.60
689	Beheira-W	1	0.48	0.42	0.85	-0.58	0.91	0.06	-0.30	-0.71	0.71	-0.15	0.03	0.13	-0.24	-0.81
689	Beheira-W	3	0.67	-0.49	-0.33	-0.40	-0.24	-0.28	0.14	0.55	-0.18	-0.05	-1.06	0.81	0.04	-0.25
690	Beheira-W	1	0.12	-0.12	-0.34	-0.10	0.88	0.85	-0.40	1.81	0.99	-0.88	0.54	-0.54	-0.87	-0.19
690	Beheira-W	2	0.74	-0.08	0.53	-0.39	0.14	-0.08	-0.76	0.46	0.22	1.46	-0.61	0.76	-0.79	0.58
692	Qalyubia	3	0.34	-0.30	0.04	-2.23	0.56	0.61	0.17	0.69	-0.74	0.27	0.52	-0.72	0.37	0.12
692	Qalyubia	3	0.48	-0.78	-0.18	-2.30	0.56	-0.12	0.32	0.45	-0.27	0.21	0.52	-0.52	0.53	0.30
692	Qalyubia	3	0.52	0.23	-0.98	-2.85	0.01	-0.18	0.69	0.32	-0.38	0.13	0.21	-1.01	0.90	0.31
692	Qalyubia	2	0.01	-1.10	-1.64	-1.17	-0.22	-0.20	0.57	1.02	-0.76	0.15	1.02	-0.63	0.80	-0.44
692	Qalyubia	1	-0.21	-2.44	-1.96	-1.36	-0.56	-0.34	1.00	0.20	0.64	-0.32	1.09	-0.37	1.14	0.07
694	Qalyubia	2	-0.33	-1.27	-2.24	-1.30	-0.56	-0.32	1.23	0.10	-1.29	-0.11	1.16	-0.43	1.32	-0.25
696	Qalyubia	3	0.36	-0.03	-1.54	-2.78	-0.16	0.48	0.76	-0.95	0.61	0.80	0.41	-1.93	0.92	2.70
696	Qalyubia	3	0.39	0.65	-1.53	-2.40	-0.38	-1.30	0.50	-0.40	0.51	1.71	0.08	-0.98	0.61	1.14
696	Qalyubia	2	-0.21	-0.60	-1.24	-1.89	0.62	0.23	0.90	0.24	-0.27	0.62	0.47	-2.02	0.99	0.23
710	Beheira-O	1	0.78	0.78	-0.89	1.98	-1.80	1.31	-0.75	-1.41	-0.60	0.48	0.68	0.90	-0.52	1.17
710	Beheira-O	3	0.22	-0.51	-0.13	0.29	0.30	0.65	-0.65	0.95	-0.54	0.00	-0.17	1.28	-0.64	-0.24
710	Beheira-O	2	-0.63	-0.66	-0.57	-0.53	0.42	-1.13	0.58	-0.12	-0.61	-0.29	-0.07	0.98	0.37	-0.26
712	Beheira-W	3	0.12	-0.56	-1.43	-0.03	-0.47	0.15	0.00	1.18	-0.26	0.05	-0.67	0.73	0.10	-0.87
721	Beheira-O	3	0.37	-0.76	0.02	0.38	0.23	0.76	-0.67	0.63	-0.51	0.04	0.15	1.44	-0.67	-0.42
721	Beheira-O	2	-0.37	-0.65	-0.74	0.83	0.68	-0.07	-0.16	-0.24	-1.19	-1.00	2.04	1.47	-0.41	-0.41
724	Beheira-O	1	0.38	2.67	1.35	0.95	0.10	0.52	-0.87	-0.99	1.56	-0.56	-0.39	-1.60	-0.84	3.32
724	Beheira-O	2	-1.63	-1.84	-1.09	-0.10	1.33	-0.92	1.09	-0.85	-2.15	-0.38	0.61	1.46	0.87	-0.94
724	Beheira-O	3	-0.07	-1.00	-0.68	0.82	-0.04	0.45	-0.24	0.73	0.07	-0.18	-0.04	1.08	-0.43	-0.77
725	Beheira-O	1	0.07	1.29	-0.40	2.43	-1.77	1.59	-1.03	-1.20	0.31	-0.37	0.79	0.74	-0.66	0.77
725	Beheira-O	2	-2.25	-2.28	-0.92	-0.07	1.55	-1.02	1.31	-0.72	-2.38	-0.61	1.07	1.41	1.05	-1.41
725	Beheira-O	3	-0.33	-1.38	-1.31	0.11	-0.17	-0.22	0.36	0.79	-0.88	-0.38	-0.33	1.15	0.52	-1.29
726	Beheira-O	3	-0.10	-1.03	-0.08	0.40	0.53	0.64	-0.64	1.43	-0.66	-0.18	0.11	1.35	-0.66	-0.50
726	Beheira-O	2	-0.78	-0.59	0.39	-0.43	0.68	-0.81	0.55	-0.26	-0.78	-0.37	0.13	0.99	0.21	-0.92
727	Beheira-O	1	-0.21	-0.15	-2.00	-1.07	-1.35	0.78	2.33	-1.06	-0.15	-0.89	-1.51	-2.55	2.41	-0.93
727	Beheira-O	3	0.07	-0.68	-0.60	0.25	0.15	0.67	-0.56	1.29	-0.43	-0.20	-0.17	1.35	-0.60	-0.32

Farm-no.	Region	Year	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo	Al	Rd
728	Beheira-O	1	-0.92	0.65	0.11	-1.13	-0.60	-1.64	1.34	-0.85	1.29	-0.78	-1.55	-0.91	1.45	-0.84
728	Beheira-O	3	0.17	-0.92	0.46	0.09	0.34	0.58	-0.61	0.70	0.02	-0.10	-0.23	1.45	-0.63	-0.43
728	Beheira-O	2	-0.21	-0.76	-0.48	0.06	1.28	-0.02	0.29	-0.93	-2.00	-0.35	0.09	1.38	0.10	0.50
729	Beheira-O	1	-0.12	-0.29	-2.75	-1.39	-1.46	0.53	2.44	-0.92	-0.42	0.71	-1.70	-2.85	2.49	-1.29
729	Beheira-O	2	-0.51	-1.15	-0.12	-0.69	1.03	-0.59	0.68	-0.02	-1.04	-0.20	-0.98	0.67	0.52	0.24
729	Beheira-O	3	0.41	-0.46	-0.30	0.16	0.13	0.61	-0.72	0.90	0.17	0.03	-0.11	1.41	-0.87	-0.20
732	Beheira-O	1	1.72	1.33	0.51	1.64	-1.47	1.74	-1.11	-0.55	0.54	0.56	0.89	-0.96	-1.01	1.64
732	Beheira-O	2	-0.59	-0.71	0.36	-0.64	0.94	-0.70	0.31	-0.22	-0.89	-0.08	0.34	0.96	0.14	-0.59
732	Beheira-O	3	0.26	-0.91	0.36	0.53	0.38	0.76	-0.62	0.72	-0.66	-0.17	-0.05	1.42	-0.61	-0.44
733	Beheira-O	1	-0.40	1.24	0.68	-0.39	-0.14	-0.47	0.43	-0.42	0.73	-0.12	-0.95	-1.31	0.36	0.79
734	Beheira-O	1	1.47	1.13	0.39	-0.41	0.82	-0.64	-0.62	-0.27	0.94	0.12	-0.52	-0.08	-0.65	0.69
734	Beheira-O	2	0.42	-0.67	0.77	0.70	0.93	-0.11	-0.88	0.05	-0.33	1.31	-0.07	0.97	-0.84	0.18
735	Beheira-O	1	0.57	2.56	0.60	0.87	-0.08	0.97	-0.88	-0.70	1.71	-0.52	-0.47	-1.72	-0.83	3.23
735	Beheira-O	2	0.84	0.19	0.40	0.20	0.37	-0.54	-0.96	0.10	-0.04	1.80	-0.43	0.90	-0.97	0.96
736	Beheira-O	1	-0.47	-1.03	-1.70	0.03	0.28	0.28	0.07	1.26	0.78	-0.32	0.37	0.20	-0.26	-0.58
736	Beheira-O	2	0.82	0.32	0.88	-0.57	0.12	0.30	-0.70	0.56	0.28	0.50	-0.61	0.50	-0.68	0.49
736	Beheira-O	3	0.73	-0.44	-0.90	-1.03	0.34	0.26	0.46	-2.21	-0.88	0.28	0.76	0.87	0.25	0.91
736	Beheira-O	3	0.52	-0.81	-0.85	-1.24	0.39	-0.14	0.70	-1.58	0.25	-0.04	0.26	0.60	0.39	-0.29
737	Beheira-W	2	0.67	-0.06	0.24	-0.65	0.05	0.43	-0.62	0.63	-0.07	0.79	-0.31	0.47	-0.43	0.14
739	Beheira-W	1	-0.15	0.23	0.01	-0.04	-0.18	-0.16	0.11	0.02	0.93	-0.50	-0.39	-0.28	0.00	0.59
739	Beheira-W	2	0.33	-0.07	0.94	-0.13	0.36	-0.12	-0.64	0.45	-0.28	1.15	-0.56	0.62	-0.50	-0.17
740	Beheira-W	1	-0.21	0.01	-1.29	-0.06	0.71	0.29	0.10	1.99	-0.71	-1.05	-0.04	-0.30	-0.16	-0.05
740	Beheira-W	2	-0.12	-0.73	1.45	0.66	1.14	-0.07	-0.92	0.34	-0.55	1.39	-0.02	0.86	-0.86	0.11
741	Beheira-W	1	-0.45	0.68	-0.17	-0.51	-0.19	-0.21	0.45	0.13	0.53	0.33	-1.16	-1.14	0.42	0.48
741	Beheira-W	2	0.41	-0.45	0.61	0.47	0.92	-0.20	-0.79	0.19	-0.34	0.82	-0.20	1.10	-0.79	0.30
743	Beheira-O	1	1.62	1.44	0.56	1.84	-1.36	1.73	-1.18	-0.71	0.12	-0.45	0.72	-0.07	-1.05	2.10
743	Beheira-O	3	0.27	-0.59	-1.25	0.29	-0.07	0.77	-0.63	1.14	0.10	0.17	-0.31	1.30	-0.67	-0.32
744	Beheira-O	2	0.21	-0.22	0.79	-0.75	0.16	0.51	-0.50	1.20	-0.30	0.16	-0.05	0.13	-0.15	-0.52
745	Beheira-W	1	-0.94	1.18	0.40	-0.29	-0.06	-0.63	0.53	-0.40	0.49	-0.29	-0.71	-1.14	0.57	0.17
753	Sharqia-W	2	-0.40	-0.20	-2.07	-1.24	-0.97	-0.46	1.62	-0.09	-0.93	-0.18	-0.38	-1.67	1.72	0.91
753	Sharqia-W	3	1.16	-0.38	-1.72	-1.15	0.45	0.59	0.09	-0.43	-0.30	0.39	0.08	-0.49	0.46	0.55
753	Sharqia-W	1	0.92	-0.06	-0.81	-0.93	0.44	0.54	-0.25	-0.16	-0.28	-0.37	0.79	0.09	0.03	0.39
754	Sharqia-W	2	0.01	0.23	-1.97	-1.20	-1.11	-0.01	1.34	-0.15	-1.04	-0.42	-0.63	-1.49	1.49	1.76
754	Sharqia-W	1	1.24	0.40	-1.33	-0.99	0.80	1.51	-0.25	-0.24	-0.28	-0.60	1.44	-1.53	0.03	1.95
754	Sharqia-W	3	0.61	-0.39	-1.18	-1.40	0.75	1.83	-0.26	-0.67	-0.99	0.20	1.77	0.03	0.15	-0.60
755	Sharqia-W	1	1.20	-0.38	0.13	-0.79	0.48	0.81	-0.06	-1.21	0.05	-0.70	0.14	-0.35	0.35	1.55
755	Sharqia-W	2	-0.83	0.28	-4.67	-3.55	-1.57	-1.05	2.96	-0.31	-0.37	-0.52	-1.11	-1.41	2.91	-1.92
755	Sharqia-W	3	-0.07	-1.09	0.28	-1.22	1.28	1.67	0.21	-0.82	-1.30	-0.30	1.59	-0.40	0.62	-1.34
756	Sharqia-W	2	-0.97	0.22	-4.28	-3.04	-1.55	-0.90	2.84	-0.23	-0.48	-0.53	-0.95	-1.71	2.80	-1.41
756	Sharqia-W	1	1.08	0.52	0.17	-1.10	0.29	0.76	-0.23	-0.41	0.28	-0.94	0.40	-0.43	0.10	0.63
756	Sharqia-W	3	0.37	-0.27	0.86	-0.68	0.94	1.37	-0.66	0.34	-0.84	-0.57	1.44	-0.11	-0.07	-0.86
757	Sharqia-W	1	1.29	0.87	-1.04	-0.84	0.63	1.24	-0.41	-1.46	-0.59	-0.61	0.98	0.17	-0.05	0.95
757	Sharqia-W	3	1.19	-0.42	-3.71	-1.38	-0.24	0.21	1.30	-1.08	-1.12	-0.22	-0.64	-0.27	1.52	-0.53
757	Sharqia-W	2	-0.48	0.91	-2.90	-2.43	-1.01	-0.62	1.76	-0.73	0.22	-0.25	-0.82	-1.36	1.95	-0.99
758	Sharqia-W	2	-0.58	0.33	-4.71	-3.38	-1.37	-0.80	2.62	-0.66	-0.28	-0.58	-0.82	-0.98	2.67	-1.95
758	Sharqia-W	3	0.46	-0.31	-0.60	-2.59	0.57	0.46	-0.71	1.00	3.35	-0.64	0.20	0.69	-0.54	-1.39
759	Sharqia-O	3	-1.23	-1.68	-2.82	-0.25	1.99	0.23	0.92	1.20	-2.33	-0.62	2.27	-1.55	1.05	-0.72
759	Sharqia-O	1	0.14	-0.20	-1.77	-1.71	-0.29	-0.42	1.68	0.83	-0.94	-1.28	-0.47	-1.94	1.63	0.45
759	Sharqia-O	2	-1.48	-1.23	-2.51	-2.21	-1.51	-0.30	2.98	0.17	-1.71	-1.11	-1.01	-1.43	2.80	-0.32
760	Sharqia-O	3	-0.59	-1.59	-1.43	0.02	1.06	0.57	0.37	0.71	-2.15	-0.08	0.72	0.06	0.66	-0.90
760	Sharqia-O	3	0.59	-0.35	1.31	-0.29	-0.38	0.16	-0.92	2.37	0.11	0.23	1.87	-1.05	-0.70	1.07
760	Sharqia-O	2	-0.88	-0.69	-0.21	-0.71	-0.18	0.09	1.18	0.08	-1.08	-0.63	0.30	-1.37	1.27	0.18
760	Sharqia-O	1	0.70	0.40	-1.18	-1.45	0.13	-0.81	0.75	0.36	-0.03	-0.72	-0.48	-1.36	0.94	0.75
761	Sharqia-O	2	0.03	0.78	-1.06	-1.57	-0.41	0.44	0.58	0.04	-0.04	0.02	0.27	-1.96	0.77	1.53
761	Sharqia-O	3	-0.46	-0.19	-3.05	-2.18	-0.35	0.25	1.33	0.82	-1.04	-0.70	-0.07	-0.81	1.43	-0.37
761	Sharqia-O	1	0.87	0.19	-0.87	-1.44	0.19	-0.32	0.42	-0.06	-0.26	0.64	-0.22	-1.29	0.60	1.07
762	Sharqia-O	3	0.62	0.40	-3.00	-0.40	-0.65	0.36	0.80	1.20	-2.04	-0.51	0.09	-1.22	0.95	0.40
762	Sharqia-O	2	-0.06	0.64	-2.69	-2.47	-0.48	-0.31	0.82	0.86	2.45	0.09	-0.43	-1.97	0.77	-0.25
762	Sharqia-O	1	0.37	0.12	-2.55	0.18	-0.68	0.71	0.40	0.22	-1.08	-1.38	0.35	0.09	0.67	-0.13
763	Sharqia-O	1	0.96	0.31	-1.40	-1.74	0.11	-0.24	1.20	0.12	-0.28	-0.58	-0.62	-2.24	1.30	0.61
763	Sharqia-O	2	-0.69	-0.23	-4.18	-2.07	-1.44	-0.60	2.35	-0.30	-1.00	-1.14	-0.39	-0.68	2.30	-0.53
764	Sharqia-O	2	-1.24	0.05	-2.89	-2.87	-1.21	-0.84	2.73	0.26	-1.21	-0.07	-0.98	-2.17	2.58	-0.52
764	Sharqia-O	1	-0.34	-0.15	-0.44	-1.52	-0.10	-0.22	0.53	1.68	-0.29	-1.48	-0.35	-0.44	0.76	-0.04

Farm-no.	Region	Year	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo	Al	Rd
764	Sharqia-O	3	0.03	0.14	-2.63	-1.89	-0.48	0.09	0.37	0.76	-0.68	1.14	-0.07	0.05	0.42	-0.02
765	Sharqia-O	1	1.88	1.07	-0.98	-2.37	0.54	0.66	0.10	0.13	-0.25	-0.62	-0.13	-1.11	0.28	1.30
766	Sharqia-O	2	-0.43	-0.17	0.11	-1.25	-0.47	0.84	0.94	-0.01	-0.89	-0.59	0.03	-1.68	1.06	1.69
767	Sharqia-O	2	-0.20	-0.25	-0.22	-1.39	-0.57	0.69	1.16	0.08	-1.35	-0.58	-0.13	-1.61	1.28	1.22
768	Sharqia-O	2	-2.73	-1.51	-3.09	-2.88	-1.81	-0.70	4.11	0.76	-1.46	-0.81	-1.35	-2.93	3.74	-1.47
768	Sharqia-O	1	1.13	-1.59	-2.39	-0.88	0.28	-0.42	0.42	0.36	-1.50	-1.30	0.56	0.72	0.65	2.56
769	Sharqia-O	2	-0.29	-0.07	-0.81	-1.51	-0.65	0.39	0.97	-0.04	-0.63	0.23	-0.53	-1.55	1.17	1.50
769	Sharqia-O	1	-1.20	-0.16	1.24	-0.84	0.70	-0.74	1.05	0.54	-0.91	-2.07	0.18	-0.97	1.15	-0.71
770	Sharqia-O	3	-0.41	1.09	-4.05	-4.54	-2.21	-2.45	2.32	0.69	-0.15	-0.19	-2.39	0.16	2.42	-0.67
770	Sharqia-O	2	-0.46	-0.29	-0.39	-1.56	-0.62	0.19	1.15	-0.05	-0.71	0.18	-0.33	-1.79	1.32	1.36
770	Sharqia-O	1	0.57	0.54	-1.96	-1.05	-0.07	0.19	0.11	1.34	-1.46	-0.79	-0.37	-0.09	0.45	1.00
771	Sharqia-O	1	0.40	0.75	-0.91	-0.86	0.18	0.39	-0.01	1.53	-1.58	-0.98	-0.62	-0.24	0.36	0.59
771	Sharqia-O	2	-0.72	0.03	-2.18	-1.57	-0.92	-0.59	1.61	-0.19	-0.42	0.24	-0.55	-1.90	1.77	0.85
772	Sharqia-O	2	-0.57	-0.23	-0.40	-1.24	-0.73	0.22	1.18	-0.07	-0.53	-0.25	-0.03	-1.72	1.29	0.82
772	Sharqia-O	3	0.65	0.29	-2.74	-1.96	-0.19	0.23	0.57	0.73	-0.13	0.29	0.15	-1.33	0.77	0.18
772	Sharqia-O	1	0.10	0.98	-0.73	-1.18	-0.11	-0.03	0.02	1.48	-0.79	-0.84	-0.61	-0.45	0.36	0.99
773	Sharqia-O	3	0.14	-0.10	-2.75	-2.40	-0.79	-0.72	1.39	0.63	-0.54	-0.54	-0.45	-0.40	1.53	-1.11
773	Sharqia-O	1	0.54	0.82	-1.61	-1.01	-0.17	0.07	-0.01	1.32	-1.04	-0.82	-0.27	-0.23	0.33	1.06
774	Sharqia-W	2	-0.30	0.53	-2.37	-1.86	-1.17	-0.25	1.19	-0.30	-0.20	0.18	-0.43	-1.54	1.46	1.68
774	Sharqia-W	1	-0.12	-0.23	-0.90	-0.97	-0.18	-0.26	0.65	-0.46	0.82	0.07	0.50	-1.74	0.84	1.12
775	Sharqia-W	2	-0.32	0.36	-1.27	-1.12	-1.02	0.05	0.90	-0.28	-0.39	-0.01	-0.22	-1.55	1.18	1.88
775	Sharqia-W	1	0.71	0.44	-2.62	-1.00	0.09	0.67	0.17	-0.43	0.00	-1.02	0.56	-0.20	0.50	0.45
775	Sharqia-W	3	0.75	-0.64	-3.12	-1.69	-0.23	0.01	0.56	-0.77	-0.02	-0.02	0.28	0.80	0.82	-0.73
776	Sharqia-W	1	1.35	0.82	-0.18	-1.09	0.54	0.63	-0.28	-1.15	-0.03	-0.71	0.23	0.22	0.05	0.13
776	Sharqia-W	2	0.06	0.73	-1.52	-1.33	-0.95	0.21	0.71	-0.05	-0.31	0.12	-0.28	-1.74	1.00	2.12
776	Sharqia-W	3	-1.90	-1.13	-1.72	-1.09	0.74	0.53	1.19	0.19	-2.00	-1.00	0.82	0.06	1.49	-2.29
777	Sharqia-W	2	-0.12	0.38	-1.27	-1.68	-0.94	0.33	0.84	0.00	0.23	0.16	-0.47	-1.91	1.05	2.19
777	Sharqia-W	1	-0.61	1.07	0.19	-0.39	-0.28	-0.86	0.53	-0.54	2.01	0.01	-1.13	-1.39	0.42	0.16
778	Qalyubia	1	-0.57	-1.07	-1.07	-2.27	0.24	-0.08	0.84	1.10	0.55	-0.73	0.44	-0.98	0.99	-0.50
784	Beheira-O	3	0.04	-0.57	-1.02	-0.17	0.14	0.54	-0.40	1.23	-0.31	0.14	-0.24	1.27	-0.49	-0.66
784	Beheira-O	2	-0.52	-0.83	0.07	-0.83	0.86	-0.37	0.41	-0.17	-1.17	-0.03	-0.32	1.13	0.22	-0.13
785	Beheira-O	1	-1.15	-0.19	0.80	-1.32	-0.70	-1.42	0.96	-0.92	0.76	-1.47	0.35	0.78	1.12	-1.78
785	Beheira-O	2	-1.89	-1.23	-0.52	0.14	0.84	0.03	0.50	0.25	-2.21	-1.17	3.17	0.96	0.34	-2.07
785	Beheira-O	3	0.13	-0.72	-0.14	0.31	0.26	0.58	-0.58	0.87	-0.27	0.12	-0.22	1.39	-0.62	-0.77
786	Beheira-O	1	-0.12	0.37	0.32	-0.24	0.08	-0.41	0.22	-0.12	0.51	-0.41	-0.74	-0.39	0.26	0.25
786	Beheira-O	3	0.39	-0.44	-0.97	0.17	0.02	0.63	-0.81	1.39	-0.43	0.22	0.08	1.29	-0.75	0.05
786	Beheira-O	2	-0.74	-0.44	1.02	-1.46	0.96	-1.42	0.84	0.28	-0.55	0.00	-1.30	0.26	0.63	-0.79
787	Beheira-O	2	-2.60	-1.96	-0.98	-0.04	1.06	-0.79	1.38	-0.40	-2.19	-0.70	1.72	0.96	1.06	-2.07
787	Beheira-O	3	0.32	-0.78	-0.38	0.39	-0.16	0.53	-0.44	0.99	-0.72	0.32	-0.12	1.20	-0.53	-0.22
788	Beheira-O	1	0.68	1.36	-0.63	1.76	-1.90	1.85	-0.81	-0.35	0.06	0.76	0.66	-0.67	-0.80	1.89
788	Beheira-O	3	0.28	-1.00	-0.04	0.76	0.39	0.74	-0.85	1.15	-0.58	0.28	0.01	1.45	-0.86	-0.32
788	Beheira-O	2	-0.36	-1.47	-0.37	-1.45	0.87	-1.32	0.91	0.09	-0.93	0.12	-0.74	1.02	0.63	-0.27
789	Beheira-O	2	-0.80	-0.89	-0.47	0.12	0.79	-0.05	0.18	-0.06	-1.79	-0.65	2.12	1.05	0.02	-0.86
789	Beheira-O	3	0.14	-0.51	-0.35	0.20	-0.07	0.90	-0.39	1.05	-0.73	0.07	-0.25	0.97	-0.43	-0.44
790	Beheira-O	3	0.28	-0.84	-0.47	0.27	-0.10	0.43	-0.33	0.70	-0.38	0.22	-0.01	1.27	-0.49	-0.58
790	Beheira-O	2	-0.45	-0.81	-0.01	-1.15	0.84	-0.91	0.93	-0.01	-1.19	-0.16	-0.38	0.79	0.48	-1.01
6771	Faiyum	3	-1.87	-3.49	-1.87	-1.76	-1.76	-2.35	1.71	2.48	2.87	0.33	0.48	-0.59	1.59	-3.47
6771	Faiyum	1	-1.08	-1.80	0.57	-1.02	-0.53	-1.23	1.20	1.95	-1.20	-1.75	1.67	-0.63	1.27	-1.05
6772	Faiyum	3	-1.35	-2.72	-0.01	-1.15	-0.50	-0.83	1.57	0.87	-0.90	-0.85	2.23	-1.09	1.72	-1.61
7821	Dakah.-Da.	3	-1.41	0.81	0.51	-2.37	-0.04	-0.29	1.32	-1.60	-0.27	-0.16	-0.38	-1.30	1.42	1.15
7822	Dakah.-Da.	3	-0.85	0.73	-0.48	-2.41	-0.21	-0.43	1.28	-1.83	-0.23	0.42	-0.19	-1.33	1.37	1.71

*) 1=2008, 2=2009, 3=2010.

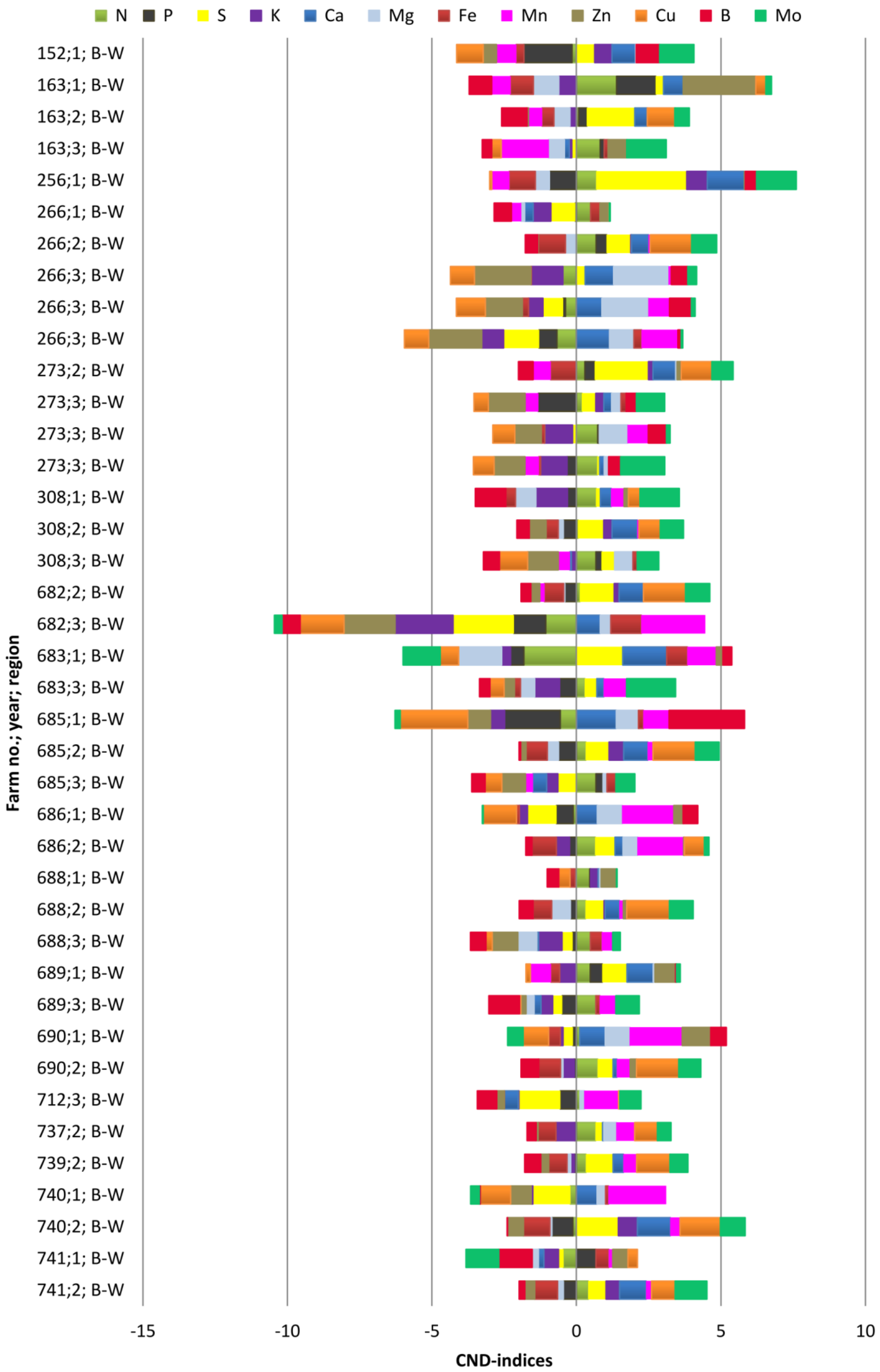


Fig. 8.10: CND-indices according to Parent and Dafir (1992) for element-concentrations in young, fully developed main stem leaf blades of organically grown cotton (*Gossypium barbadense*), sampled in 2008-2010.

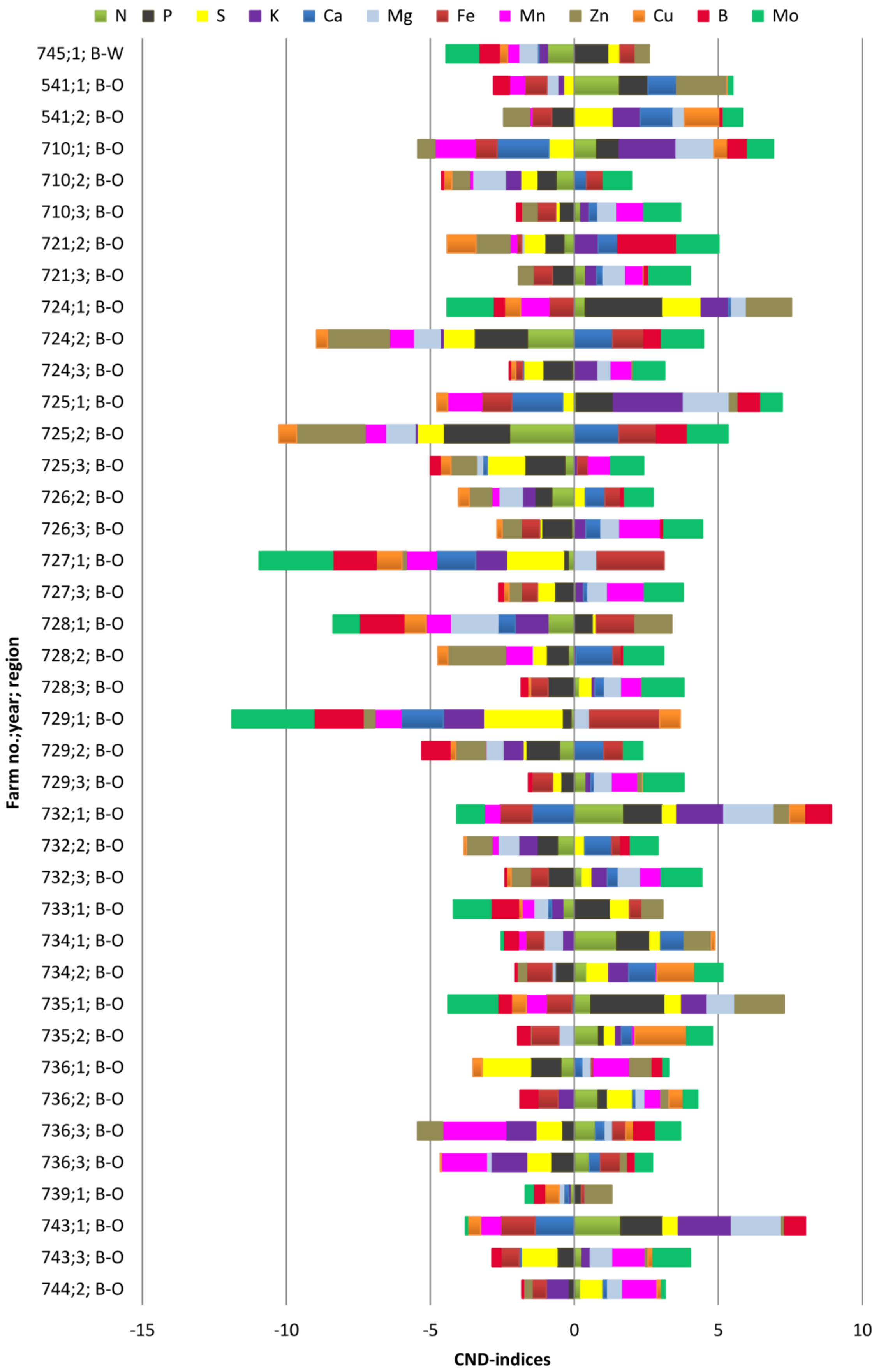


Fig. 8.10 continued; Year: 1=2008, 2=2009, 3=2010; region: B-W=Beheira-west, B-O=Beheira-east, S-W=Sharqia-west, S-O=Sharqia-east, Dah=Dakahlia/Damietta, Qal=Qalyubia, Fai=Faiyum.

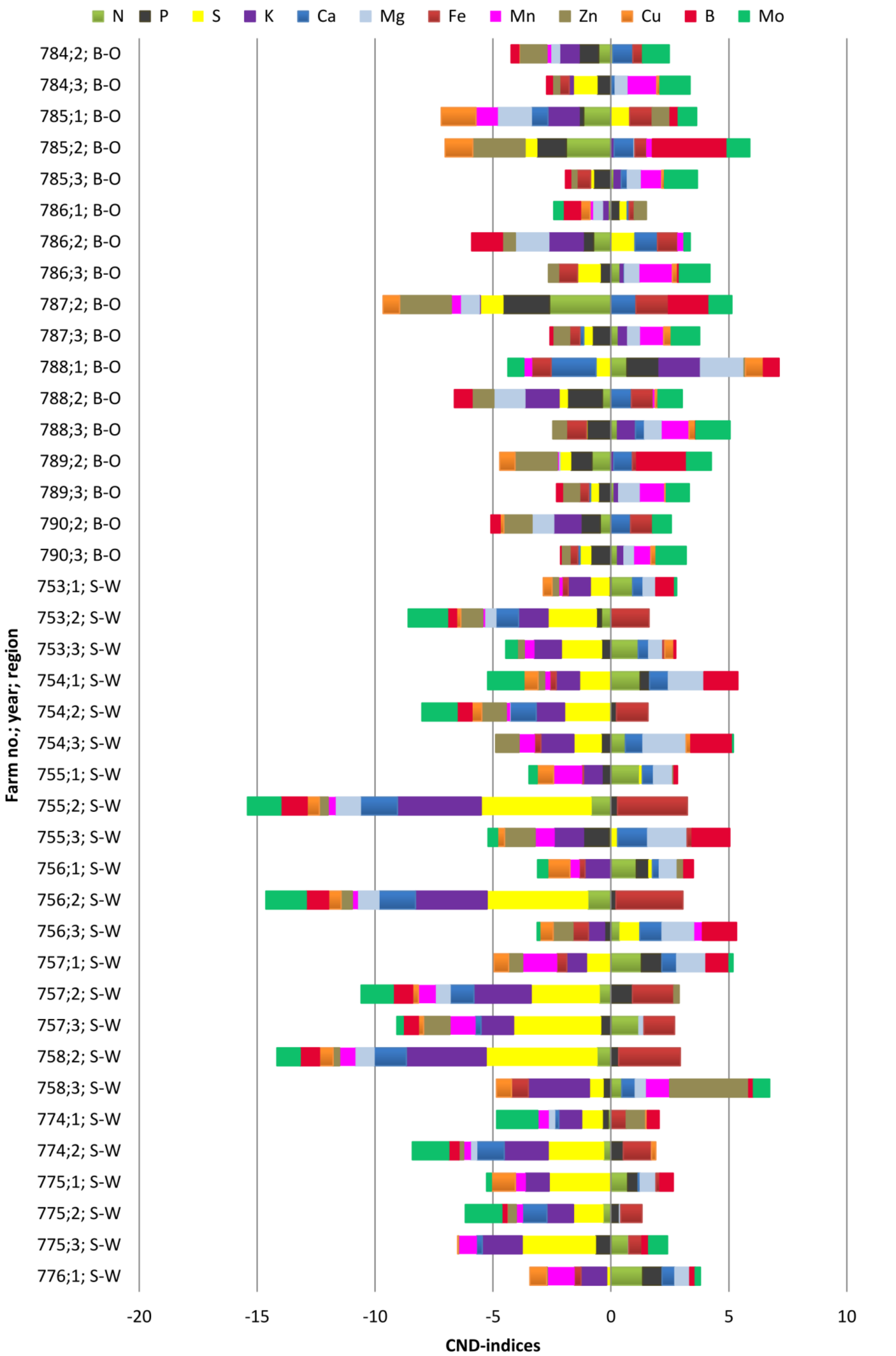


Fig. 8.10 continued

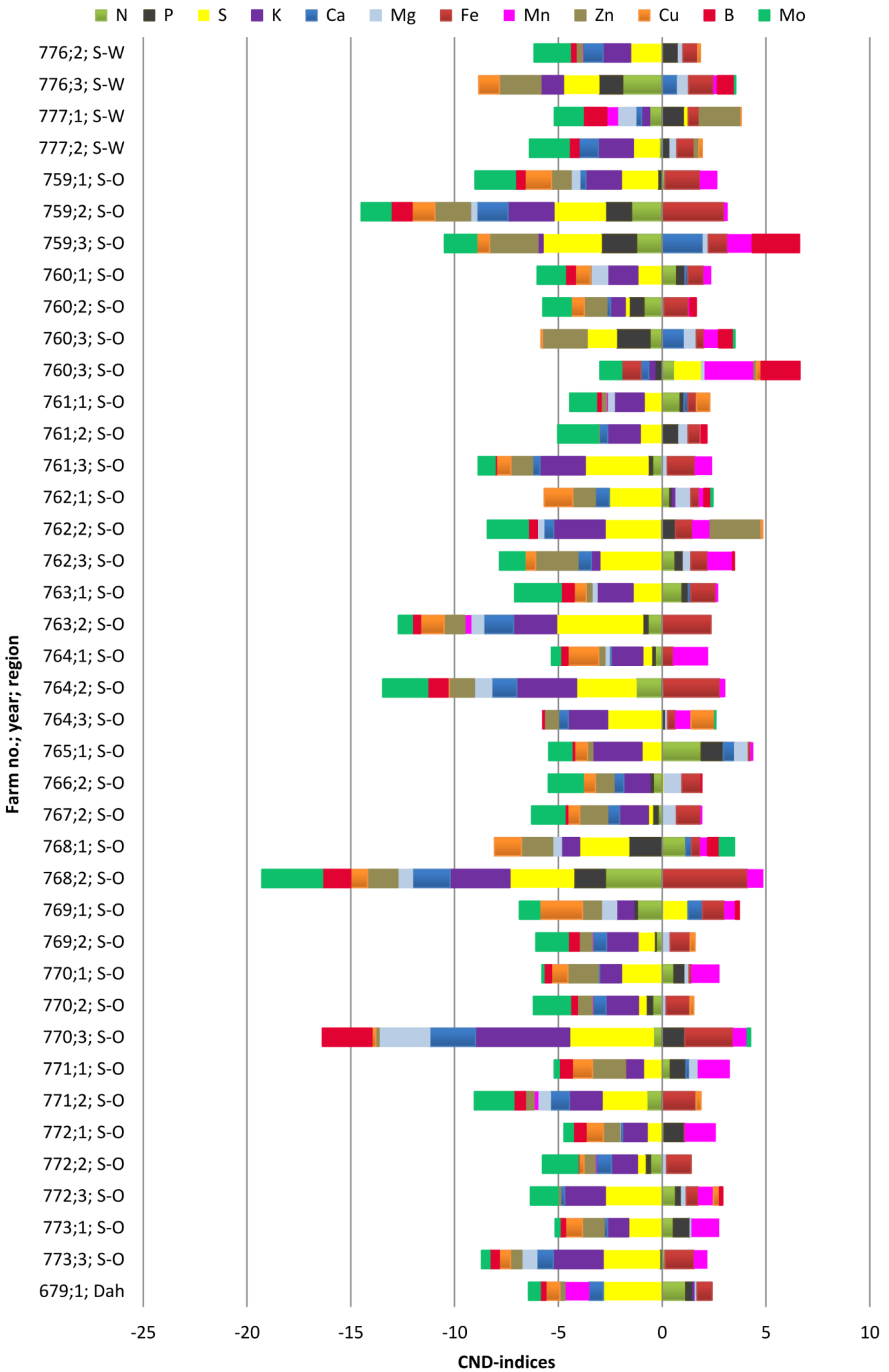


Fig. 8.10 continued

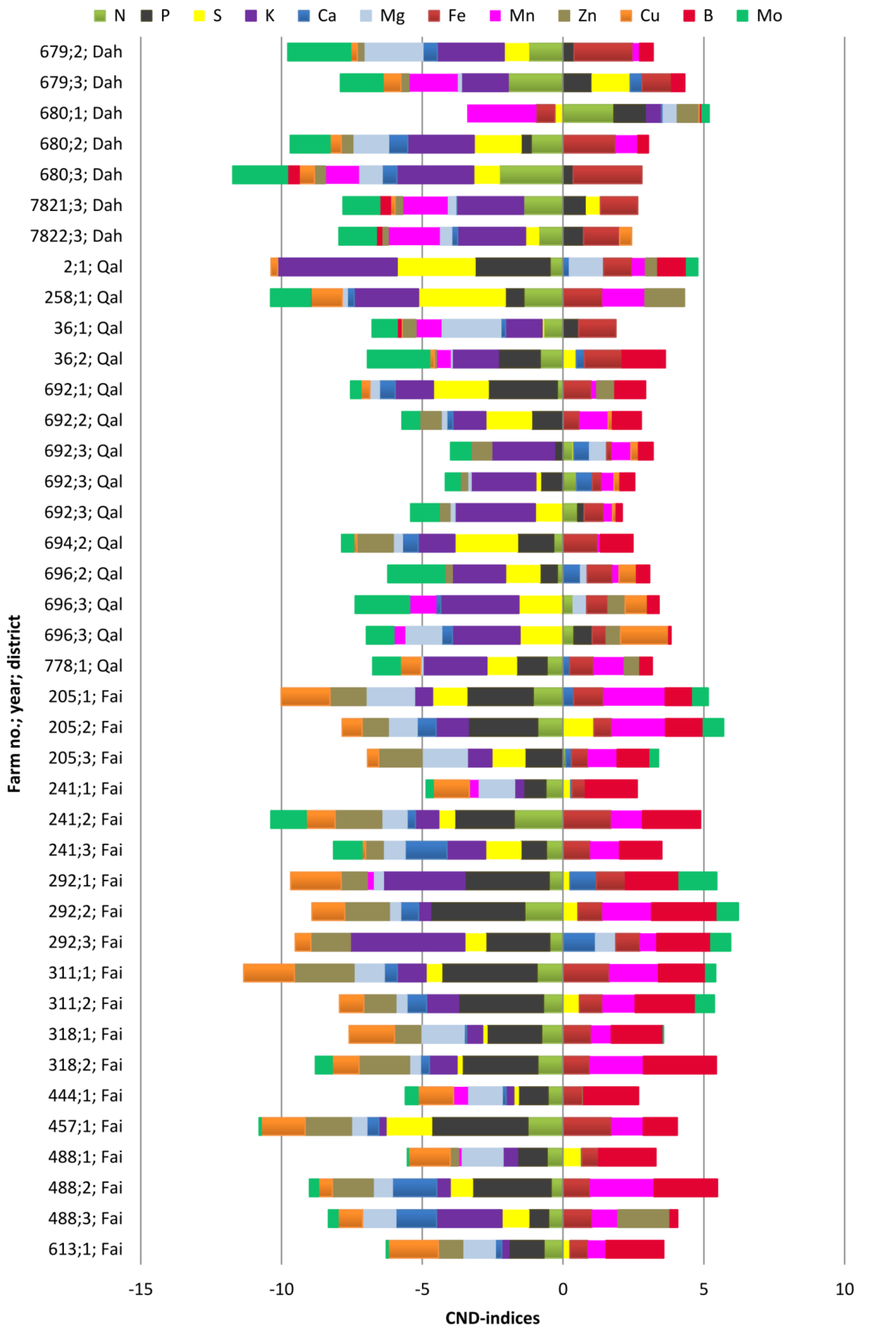


Fig. 8.10 continued

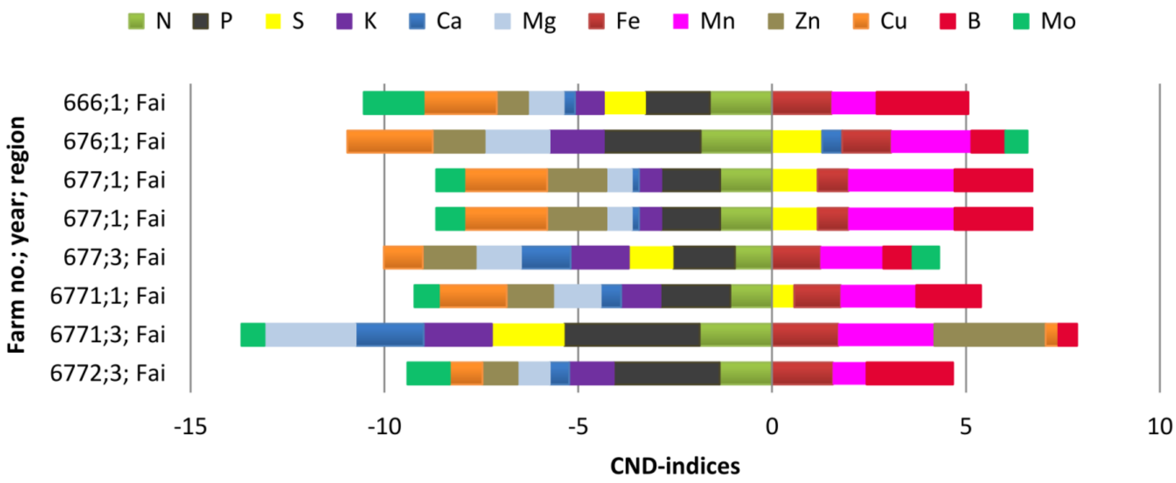


Fig. 8.10 continued

Tab. 8.33: Mean CND-indices with respect to 3 different years of sampling for organically grown cotton (*Gossypium barbadense*).

8.33.1 CND-indices diagnosing deficiency

Element	Year	N	Mean	Standard deviation	Minimum	Maximum
N	2008	74	0.37	0.51	0.00	1.84
	2009	68	0.56	0.64	0.00	2.73
	2010	66	0.30	0.56	0.00	2.25
	Total	208	0.41	0.58	0.00	2.73
P	2008	74	0.62	0.93	0.00	3.40
	2009	68	0.67	0.84	0.00	3.34
	2010	66	0.64	0.67	0.00	3.49
	Total	208	0.64	0.82	0.00	3.49
S	2008	74	0.72	0.89	0.00	3.10
	2009	68	0.93	1.26	0.00	4.71
	2010	66	0.97	1.03	0.00	4.05
	Total	208	0.87	1.07	0.00	4.71
K	2008	74	0.78	0.77	0.00	4.25
	2009	68	1.03	0.94	0.00	3.55
	2010	66	1.08	1.09	0.00	4.54
	Total	208	0.96	0.94	0.00	4.54
Ca	2008	74	0.26	0.47	0.00	1.90
	2009	68	0.43	0.54	0.00	1.81
	2010	66	0.23	0.45	0.00	2.21
	Total	208	0.31	0.49	0.00	2.21
Mg	2008	74	0.41	0.52	0.00	1.72
	2009	68	0.45	0.49	0.00	2.11
	2010	66	0.25	0.53	0.00	2.45
	Total	208	0.37	0.52	0.00	2.45
Fe	2008	74	0.18	0.33	0.00	1.18
	2009	68	0.19	0.33	0.00	0.96
	2010	66	0.19	0.29	0.00	0.92
	Total	208	0.19	0.31	0.00	1.18
Mn	2008	74	0.35	0.48	0.00	2.44
	2009	68	0.14	0.24	0.00	0.93
	2010	66	0.28	0.55	0.00	2.21
	Total	208	0.26	0.45	0.00	2.44
Zn	2008	74	0.40	0.55	0.00	2.11
	2009	68	0.77	0.65	0.00	2.38
	2010	66	0.69	0.62	0.00	2.33

Element	Year	N	Mean	Standard deviation	Minimum	Maximum
	Total	208	0.61	0.63	0.00	2.38
Cu	2008	74	0.81	0.67	0.00	2.34
	2009	68	0.29	0.37	0.00	1.17
	2010	66	0.31	0.36	0.00	1.52
	Total	208	0.48	0.55	0.00	2.34
B	2008	74	0.26	0.42	0.00	1.70
	2009	68	0.32	0.37	0.00	1.35
	2010	66	0.17	0.36	0.00	2.39
	Total	208	0.25	0.38	0.00	2.39
Mo	2008	74	0.59	0.72	0.00	2.85
	2009	68	0.70	0.84	0.00	2.93
	2010	66	0.34	0.55	0.00	1.94
	Total	208	0.55	0.73	0.00	2.93

8.33.2 CND-indices diagnosing excess

Element	Year	N	Mean	Standard deviation	Minimum	Maximum
N	2008	74	0.43	0.57	0.00	1.88
	2009	68	0.10	0.22	0.00	0.84
	2010	66	0.28	0.31	0.00	1.19
	Total	208	0.28	0.42	0.00	1.88
P	2008	74	0.41	0.60	0.00	2.67
	2009	68	0.12	0.22	0.00	0.91
	2010	66	0.10	0.24	0.00	1.09
	Total	208	0.22	0.43	0.00	2.67
S	2008	74	0.27	0.52	0.00	3.13
	2009	68	0.30	0.48	0.00	1.86
	2010	66	0.11	0.28	0.00	1.37
	Total	208	0.23	0.45	0.00	3.13
K	2008	74	0.19	0.51	0.00	2.43
	2009	68	0.08	0.20	0.00	0.93
	2010	66	0.09	0.18	0.00	0.82
	Total	208	0.12	0.35	0.00	2.43
Ca	2008	74	0.27	0.38	0.00	1.52
	2009	68	0.37	0.45	0.00	1.55
	2010	66	0.28	0.41	0.00	1.99
	Total	208	0.31	0.42	0.00	1.99
Mg	2008	74	0.33	0.51	0.00	1.85
	2009	68	0.09	0.18	0.00	0.84
	2010	66	0.42	0.47	0.00	1.91
	Total	208	0.28	0.44	0.00	1.91
Fe	2008	74	0.53	0.60	0.00	2.44
	2009	68	0.92	0.90	0.00	4.11
	2010	66	0.49	0.60	0.00	2.44
	Total	208	0.64	0.74	0.00	4.11
Mn	2008	74	0.54	0.77	0.00	2.74
	2009	68	0.31	0.55	0.00	2.28
	2010	66	0.68	0.59	0.00	2.48
	Total	208	0.51	0.66	0.00	2.74
Zn	2008	74	0.35	0.55	0.00	2.51
	2009	68	0.05	0.30	0.00	2.45
	2010	66	0.16	0.59	0.00	3.35
	Total	208	0.19	0.51	0.00	3.35
Cu	2008	74	0.06	0.17	0.00	0.76
	2009	68	0.32	0.53	0.00	1.80
	2010	66	0.12	0.28	0.00	1.71
	Total	208	0.17	0.37	0.00	1.80
B	2008	74	0.60	0.74	0.00	2.61
	2009	68	0.41	0.80	0.00	3.17
	2010	66	0.39	0.61	0.00	2.27
	Total	208	0.47	0.72	0.00	3.17
Mo	2008	74	0.16	0.35	0.00	1.38

Element	Year	N	Mean	Standard deviation	Minimum	Maximum
	2009	68	0.44	0.48	0.00	1.47
	2010	66	0.55	0.59	0.00	1.70
	Total	208	0.38	0.50	0.00	1.70

Tab. 8.34: Mean regional CND-indices with respect to 7 different Egyptian regions for element concentrations in organically grown cotton (*Gossypium barbadense*).

8.34.1: CND-indices diagnosing deficiency

Element	Region	N	Mean	Standard deviation	Minimum	Maximum
N	Beheira-W	41	0.17	0.37	0.00	1.82
	Beheira-O	56	0.33	0.58	0.00	2.60
	Sharqia-W	27	0.25	0.43	0.00	1.90
	Sharqia-O	35	0.40	0.59	0.00	2.73
	Dakahlia-Dam.	8	1.10	0.81	0.00	2.25
	Qalyubia	14	0.33	0.42	0.00	1.39
	Faiyum	27	0.96	0.48	0.00	1.87
	Total	208	0.41	0.58	0.00	2.73
P	Beheira-W	41	0.36	0.47	0.00	1.93
	Beheira-O	56	0.61	0.53	0.00	2.28
	Sharqia-W	27	0.20	0.32	0.00	1.13
	Sharqia-O	35	0.31	0.53	0.00	1.68
	Dakahlia-Dam.	8	0.04	0.12	0.00	0.34
	Qalyubia	14	0.88	0.86	0.00	2.65
	Faiyum	27	2.09	0.88	0.69	3.49
	Total	208	0.64	0.82	0.00	3.49
S	Beheira-W	41	0.26	0.50	0.00	2.10
	Beheira-O	56	0.44	0.58	0.00	2.75
	Sharqia-W	27	1.70	1.44	0.00	4.71
	Sharqia-O	35	1.71	1.19	0.00	4.18
	Dakahlia-Dam.	8	0.89	0.97	0.00	2.83
	Qalyubia	14	1.31	1.01	0.00	3.10
	Faiyum	27	0.51	0.59	0.00	1.87
	Total	208	0.87	1.07	0.00	4.71
K	Beheira-W	41	0.38	0.43	0.00	2.01
	Beheira-O	56	0.31	0.47	0.00	1.46
	Sharqia-W	27	1.49	0.82	0.39	3.55
	Sharqia-O	35	1.52	0.92	0.00	4.54
	Dakahlia-Dam.	8	1.74	1.11	0.00	2.73
	Qalyubia	14	2.14	0.82	1.17	4.25
	Faiyum	27	1.08	0.87	0.25	4.06
	Total	208	0.96	0.94	0.00	4.54
Ca	Beheira-W	41	0.05	0.12	0.00	0.48
	Beheira-O	56	0.24	0.53	0.00	1.90
	Sharqia-W	27	0.47	0.57	0.00	1.57
	Sharqia-O	35	0.50	0.56	0.00	2.21
	Dakahlia-Dam.	8	0.33	0.30	0.00	0.69
	Qalyubia	14	0.16	0.21	0.00	0.56
	Faiyum	27	0.49	0.55	0.00	1.76
	Total	208	0.31	0.49	0.00	2.21
Mg	Beheira-W	41	0.22	0.33	0.00	1.49
	Beheira-O	56	0.29	0.45	0.00	1.64
	Sharqia-W	27	0.19	0.34	0.00	1.05
	Sharqia-O	35	0.28	0.47	0.00	2.45
	Dakahlia-Dam.	8	0.63	0.74	0.00	2.10
	Qalyubia	14	0.35	0.61	0.00	2.11
	Faiyum	27	1.01	0.52	0.00	2.35
	Total	208	0.37	0.52	0.00	2.45
Fe	Beheira-W	41	0.32	0.34	0.00	0.94
	Beheira-O	56	0.38	0.38	0.00	1.18
	Sharqia-W	27	0.12	0.20	0.00	0.71

Element	Region	N	Mean	Standard deviation	Minimum	Maximum
	Sharqia-O	35	0.03	0.16	0.00	0.92
	Dakahlia-Dam.	8	0.08	0.24	0.00	0.67
	Qalyubia	14	0.00	0.00	0.00	0.00
	Faiyum	27	0.00	0.00	0.00	0.00
	Total	208	0.19	0.31	0.00	1.18
Mn	Beheira-W	41	0.19	0.33	0.00	1.64
	Beheira-O	56	0.34	0.49	0.00	2.21
	Sharqia-W	27	0.47	0.41	0.00	1.46
	Sharqia-O	35	0.02	0.06	0.00	0.30
	Dakahlia-Dam.	8	1.24	0.86	0.00	2.44
	Qalyubia	14	0.20	0.35	0.00	0.95
	Faiyum	27	0.04	0.12	0.00	0.51
	Total	208	0.26	0.45	0.00	2.44
Zn	Beheira-W	41	0.44	0.56	0.00	1.95
	Beheira-O	56	0.57	0.66	0.00	2.38
	Sharqia-W	27	0.43	0.51	0.00	2.00
	Sharqia-O	35	0.87	0.64	0.00	2.33
	Dakahlia-Dam.	8	0.26	0.12	0.00	0.41
	Qalyubia	14	0.31	0.40	0.00	1.29
	Faiyum	27	1.07	0.60	0.00	2.11
	Total	208	0.61	0.63	0.00	2.38
Cu	Beheira-W	41	0.41	0.53	0.00	2.34
	Beheira-O	56	0.24	0.34	0.00	1.47
	Sharqia-W	27	0.38	0.34	0.00	1.02
	Sharqia-O	35	0.59	0.53	0.00	2.07
	Dakahlia-Dam.	8	0.33	0.27	0.00	0.67
	Qalyubia	14	0.19	0.33	0.00	1.11
	Faiyum	27	1.24	0.62	0.00	2.20
	Total	208	0.48	0.55	0.00	2.34
B	Beheira-W	41	0.35	0.34	0.00	1.16
	Beheira-O	56	0.29	0.43	0.00	1.70
	Sharqia-W	27	0.29	0.39	0.00	1.13
	Sharqia-O	35	0.37	0.49	0.00	2.39
	Dakahlia-Dam.	8	0.16	0.18	0.00	0.41
	Qalyubia	14	0.01	0.04	0.00	0.13
	Faiyum	27	0.00	0.00	0.00	0.00
	Total	208	0.25	0.38	0.00	2.39
Mo	Beheira-W	41	0.12	0.32	0.00	1.29
	Beheira-O	56	0.24	0.62	0.00	2.85
	Sharqia-W	27	0.82	0.73	0.00	1.91
	Sharqia-O	35	1.13	0.79	0.00	2.93
	Dakahlia-Dam.	8	1.29	0.71	0.00	2.23
	Qalyubia	14	1.01	0.66	0.00	2.21
	Faiyum	27	0.36	0.45	0.00	1.54
	Total	208	0.55	0.73	0.00	2.93

8.34.2: CND-indices diagnosing excess

Element	Region	N	Mean	Standard deviation	Minimum	Maximum
N	Beheira-W	41	0.35	0.33	0.00	1.39
	Beheira-O	56	0.28	0.44	0.00	1.72
	Sharqia-W	27	0.46	0.53	0.00	1.35
	Sharqia-O	35	0.28	0.43	0.00	1.88
	Dakahlia-Dam.	8	0.37	0.70	0.00	1.81
	Qalyubia	14	0.15	0.21	0.00	0.52
	Faiyum	27	0.00	0.02	0.00	0.10
	Total	208	0.28	0.42	0.00	1.88
P	Beheira-W	41	0.13	0.30	0.00	1.36
	Beheira-O	56	0.30	0.62	0.00	2.67
	Sharqia-W	27	0.30	0.34	0.00	1.07
	Sharqia-O	35	0.25	0.36	0.00	1.09
	Dakahlia-Dam.	8	0.60	0.39	0.00	1.16

Element	Region	N	Mean	Standard deviation	Minimum	Maximum
	Qalyubia	14	0.10	0.22	0.00	0.65
	Faiyum	27	0.00	0.00	0.00	0.00
	Total	208	0.22	0.43	0.00	2.67
S	Beheira-W	41	0.51	0.67	0.00	3.13
	Beheira-O	56	0.22	0.36	0.00	1.35
	Sharqia-W	27	0.06	0.18	0.00	0.86
	Sharqia-O	35	0.08	0.30	0.00	1.31
	Dakahlia-Dam.	8	0.24	0.49	0.00	1.37
	Qalyubia	14	0.04	0.13	0.00	0.47
	Faiyum	27	0.29	0.44	0.00	1.29
	Total	208	0.23	0.45	0.00	3.13
K	Beheira-W	41	0.10	0.20	0.00	0.71
	Beheira-O	56	0.36	0.58	0.00	2.43
	Sharqia-W	27	0.00	0.00	0.00	0.00
	Sharqia-O	35	0.01	0.03	0.00	0.18
	Dakahlia-Dam.	8	0.08	0.19	0.00	0.53
	Qalyubia	14	0.00	0.00	0.00	0.00
	Faiyum	27	0.00	0.00	0.00	0.00
	Total	208	0.12	0.35	0.00	2.43
Ca	Beheira-W	41	0.53	0.45	0.00	1.52
	Beheira-O	56	0.41	0.44	0.00	1.55
	Sharqia-W	27	0.30	0.37	0.00	1.28
	Sharqia-O	35	0.15	0.39	0.00	1.99
	Dakahlia-Dam.	8	0.06	0.15	0.00	0.42
	Qalyubia	14	0.18	0.24	0.00	0.62
	Faiyum	27	0.12	0.30	0.00	1.16
	Total	208	0.31	0.42	0.00	1.99
Mg	Beheira-W	41	0.27	0.45	0.00	1.91
	Beheira-O	56	0.41	0.50	0.00	1.85
	Sharqia-W	27	0.50	0.57	0.00	1.83
	Sharqia-O	35	0.19	0.25	0.00	0.84
	Dakahlia-Dam.	8	0.07	0.18	0.00	0.50
	Qalyubia	14	0.18	0.36	0.00	1.21
	Faiyum	27	0.03	0.14	0.00	0.72
	Total	208	0.28	0.44	0.00	1.91
Fe	Beheira-W	41	0.12	0.23	0.00	1.06
	Beheira-O	56	0.35	0.56	0.00	2.44
	Sharqia-W	27	0.80	0.91	0.00	2.96
	Sharqia-O	35	1.04	0.93	0.00	4.11
	Dakahlia-Dam.	8	1.35	0.78	0.00	2.44
	Qalyubia	14	0.86	0.39	0.17	1.40
	Faiyum	27	1.05	0.38	0.47	1.72
	Total	208	0.64	0.74	0.00	4.11
Mn	Beheira-W	41	0.49	0.64	0.00	2.20
	Beheira-O	56	0.37	0.49	0.00	1.43
	Sharqia-W	27	0.06	0.20	0.00	1.00
	Sharqia-O	35	0.61	0.60	0.00	2.37
	Dakahlia-Dam.	8	0.13	0.28	0.00	0.80
	Qalyubia	14	0.44	0.48	0.00	1.51
	Faiyum	27	1.33	0.84	0.00	2.74
	Total	208	0.51	0.66	0.00	2.74
Zn	Beheira-W	41	0.19	0.44	0.00	2.51
	Beheira-O	56	0.23	0.46	0.00	1.75
	Sharqia-W	27	0.26	0.74	0.00	3.35
	Sharqia-O	35	0.07	0.41	0.00	2.45
	Dakahlia-Dam.	8	0.10	0.27	0.00	0.77
	Qalyubia	14	0.30	0.42	0.00	1.40
	Faiyum	27	0.18	0.65	0.00	2.87
	Total	208	0.19	0.51	0.00	3.35
Cu	Beheira-W	41	0.39	0.56	0.00	1.48
	Beheira-O	56	0.17	0.36	0.00	1.80
	Sharqia-W	27	0.04	0.09	0.00	0.39
	Sharqia-O	35	0.09	0.23	0.00	1.14
	Dakahlia-Dam.	8	0.06	0.15	0.00	0.42
	Qalyubia	14	0.28	0.48	0.00	1.71

Element	Region	N	Mean	Standard deviation	Minimum	Maximum
	Faiyum	27	0.01	0.06	0.00	0.33
	Total	208	0.17	0.37	0.00	1.80
B	Beheira-W	41	0.20	0.46	0.00	2.61
	Beheira-O	56	0.31	0.63	0.00	3.17
	Sharqia-W	27	0.42	0.57	0.00	1.77
	Sharqia-O	35	0.19	0.50	0.00	2.27
	Dakahlia-Dam.	8	0.17	0.23	0.00	0.48
	Qalyubia	14	0.61	0.48	0.00	1.53
	Faiyum	27	1.68	0.60	0.27	2.59
	Total	208	0.47	0.72	0.00	3.17
Mo	Beheira-W	41	0.56	0.50	0.00	1.70
	Beheira-O	56	0.80	0.54	0.00	1.47
	Sharqia-W	27	0.08	0.20	0.00	0.80
	Sharqia-O	35	0.03	0.13	0.00	0.72
	Dakahlia-Dam.	8	0.03	0.09	0.00	0.26
	Qalyubia	14	0.03	0.11	0.00	0.40
	Faiyum	27	0.25	0.37	0.00	1.34
	Total	208	0.38	0.50	0.00	1.70

CURRICULUM VITAE

PERSONAL DETAILS

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2 children (15, 23)

PROFESSIONAL CAREER

since July 2010	**Management assistant** Association of German Agricultural Analytic and Research Institutes (VDLUFA e.V.), Speyer (July 2010-August 2011 on part-time basis, since September 2011 on full-time basis)
October 1991-June 2010	**Scientific employee** Association for Technology and Structures in Agriculture (KTBL) e. V., Darmstadt, department „Environment and Energy“
January 2005-June 2010	Manager of the Scientific Advisory Board on Fertilizer Issues, Federal Ministry of Food, Agriculture and Consumer Protection (as employee of KTBL)
March 2007-October 2007	Delegation to the Federal Ministry of Food, Agriculture and Consumer Protection, department of plant production, during the amendment of the fertilizer ordinance, Bonn (as employee of KTBL)
February 1990-September 1991	**Project engineer/manager of branch** Dr. Reinhold Sonnenburg, Hungen (Waste water treatment/urban water supply and sanitation), Management of the branch-office in Hildritzhausen
April 1987-July 1987	**Trainee** German Technical Coorporation (GTZ), Nyabisindu, Rwanda Survey among farmers on local fallow systems
1984-1988	**Scientific assistant worker** During the university studies at following institutes: Institute for Soil Science, University of Hohenheim Institute for Plant Production in the Tropics and Subtropics, University of Hohenheim Institute for Sanitary Engineering, Water Quality and Solid Waste Management, University of Stuttgart

1981-1985	**Practical agricultural training** Twelve months on different farms
June 1980-June 1981	**Foreign language correspondence clerk** Indo-German Society e. V., Stuttgart

PROFESSIONAL QUALIFICATION

September 1981-February 1988	**University: General Agricultural Engineering** University of Hohenheim
September 1985- December 1986	**Diploma „comparing microbiological examinations of biofilters“** Institute for Sanitary Engineering, Water Quality and Solid Waste Management, University of Stuttgart
Since July 2010	**Visiting scientist** Julius Kühn-Institute (JKI), Federal Research Centre for Cultivated Plants

EDUCATION

June 1977	**General matriculation standard** Max-Planck-Gymnasium, Schorndorf

LANGUAGE EDUCATION

September 1978-June 1980	**Abraham Moss Center/Salford College of Technology: language training** English: Cambridge Certificate of Proficiency French: Certificat Pratique de Francais Commercial et Économique de la Chambre de Commerce et d'Industrie de Paris
October 1988-February 1990	**Rwanda** 5 months training of languanges (French/Kinyarwanda) and applied geography (Deutscher Entwicklungsdienst ded)

FURTHER KNOWLEDGE

Good PC-skills (Microsoft-Office, SPSS, Mathematica)

INTERESTS AND ACTIVITIES

enthusiastic in endurance sports like running, biking and swimming

intercultural relations, travelling